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TABLE OF CONTENTS ON PAGE TWO

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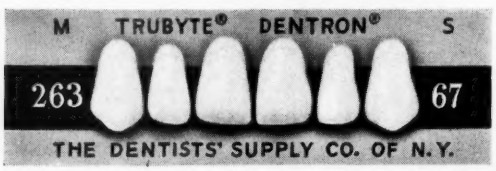

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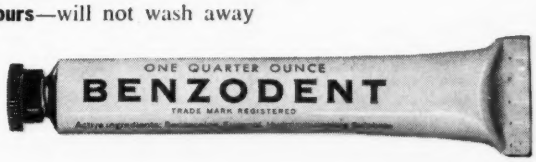

The Journal of Prosthetic Dentistry

CONTENTS FOR SEPTEMBER, 1953

Through the Eyes of the Editor. Carl O. Boucher, D.D.S., Columbus, Ohio 589

Dental Terminology. Victor H. Sears, D.D.S., Salt Lake City, Utah 592

Report of the Committee on Principles, Practices, and Nomenclature. C. H. Schuyler, New York, N. Y., L. G. Jordan, Washington, D. C., and V. H. Sears, Salt Lake City, Utah 595

Thirty Years of Nonanatomic Teeth. Victor H. Sears, D.D.S., Salt Lake City, Utah 596

The Face-Bow, Its Significance and Application. Thure Brandrup-Wognsen, L.D.S. (Sweden), Stockholm, Sweden 618

Physiologic and Neurologic Occlusion. Thomas E. J. Shanahan, D.D.S., Brooklyn, N. Y. 631

Occlusion in Prosthodontics. Carl O. Boucher, D.D.S., Columbus, Ohio 633

A Complete Standardized Pre-Extraction Record. Howard J. Merkeley, D.D.S., M.D.S., Winnipeg, Manitoba 657

Trouble Shooting in Full Denture Construction. C. A. Kennedy, Jr., B.S., D.D.S., Taylorsville, Miss. 660

Some Psychologic Aspects of Denture-Stimulated Gagging. Commander Henry A. Collett, D.C., United States Navy, and Lieutenant (jg) Dennie L. Briggs, M.S.C., United States Naval Reserve, New London, Conn. 665

Applied Psychology, an Essential Adjunct in Successful Denture Service. Henry C. Parker, D.D.S., Charlotte, N. C. 672

Premedication in Prosthodontics. Niels Bjorn Jorgensen, D.D.S., Loma Linda, Calif. 675

Nutrition Therapy by Dentists. Dangers, Advantages, Technique. J. C. Almy Harding, D.D.S., San Diego, Calif. 682

The Physiologic Aspects of Partial Denture Restorations. Raymond L. Girardot, D.D.S., Detroit, Mich. 689

The Physiologic Approach to Partial Denture Design. Colonel Ellsworth K. Kelly, Dental Corps, United States Army, Tacoma, Wash. 699

An Analysis of the Use and Relative Value of the Precision Attachment and the Clasp in Partial Denture Planning. Clyde H. Schuyler, D.D.S., New York, N. Y. 711

An Esthetic Masking Cement for Prosthetic Denture Clasps. Austin H. Kutscher, D.D.S., New York, N. Y. 715

Fixed Bridges Without Soldering. Victor Penzer, D.M.D., Jamaica Plain, Mass. 718

Masticatory Pressures Exerted With Implant Dentures as Compared With Soft-Tissue-Borne Dentures. John P. Knowlton, D.D.S., Seattle, Wash. 721

A Simplified Device to Attach the Distal Extension to the Denture of a Cleft Palate Patient. Jerome C. Strain, D.D.S., San Francisco, Calif. 727

Readers' Round Table

Readers' Round Table 731

News and Notes

Announcements 732

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THE JOURNAL OF PROSTHETIC DENTISTRY

Vol. 3 September, 1953 No. 5

THROUGH THE EYES OF THE EDITOR

Victor H. Sears discusses dental terminology on the basis of the origin of words. He finds many shortcomings in the common usage of terms in dentistry. This is all too true. Habits of a lifetime are hard to break. But some of them—those that are bad—must be broken. Breaking bad habits of speech and writing is even more difficult than breaking other habits. We have to *learn* to care.

Nomenclature in prosthodontia, like nomenclature in dentistry, is constantly changing. The Committee on Principles, Practices, and Nomenclature of the Academy of Denture Prosthetics presented a long list of proposed terms and definitions to the Academy in 1952. The Academy accepted nineteen of these terms without objection. These were published in the J. PROS. DEN. **2**:573-574, 1952.

Another list of terms and definitions was presented to the Academy at Los Angeles in 1953. Of these, six were accepted without objection.

Progress in prosthodontic nomenclature is slow because of habit, previous training, differences in concepts, geographical colloquialism, and the influence of other specialties. It will take time and much patience and understanding to resolve the many differences in nomenclature. It is to be hoped that it will not take too much time. The profession needs "handles" for ideas that are accurate and readily understood by all. The terms agreed upon by the Academy of Denture Prosthetics are steps toward the objective of an accurate usable nomenclature. It will take time and care to develop the habit of using these terms, but it should be worth the effort.

Victor H. Sears reports on thirty years of nonanatomic teeth. In this time many forms of teeth have been devised that do not have the imitation of nature's tooth form as the primary consideration. The objectives of the inventors of these nonanatomic tooth forms have varied widely. This variation in objectives is as significant as the tooth forms themselves. It indicates the casting about in many directions for a solution to mechanical problems involved in denture construction. The author has done a terrific job to bring together in a single article the significant tooth forms together with terse statements of the thinking of the inventors. The article should serve as a background for further study of the problem of posterior tooth form.

Thure Brandrup-Wognsen discusses the significance and application of the face-bow on the basis of a short historical survey of the ideas connected with its use. The survey with its illustrations constitutes a fine reference to this subject. He concludes that casts must be mounted in the articulator with the occlusal plane in the same relative position to the horizontal as the occlusal plane of the natural teeth is related to the horizontal when the head is in a vertical position. We agree that the orientation of the casts to the opening axis of the articulator should duplicate the orientation of the jaws to their opening axis, but we question the necessity for mounting the casts at *any* specific level in the articulator. Certainly, the inclination of the condylar guidances on the articulator will vary with the level at which the casts are mounted. However, the inclination of the condylar guidances is entirely relative to the inclination of the occlusal plane. If the centric relation registration and the protrusive registration are correct, the condylar inclinations will also be correct, provided the distances between

every point on the casts and the opening axis are correct. The number of degrees registered on the condylar guidances is important only in relation to the level at which the casts are mounted. Tooth inclines can be properly related to each other and to the condylar mechanism at any level of cast mounting. We might ask, what is the condylar inclination when the patient (or the articulator) is resting on his back? There is one advantage in having casts oriented in the same plane as the jaws are in the head when it is in an upright position. The anterior teeth are more easily arranged for esthetics, since they are being set on the trial dentures in the same orientation as they will have in the mouth.

Thomas E. J. Shanahan divides jaw movements into two classes in his discussion of physiologic and neurologic occlusions. He calls the cyclic (vertical) movements physiologic movements, and the contacts of bruxism (lateral and protrusive) movements are called neurologic movements. This seems like a logical classification. The suggested procedures for checking and eliminating cuspal interferences in each type of movement seem sound, except that the testing and correction of occlusal errors in the mouth may be inefficient because of the shifting of bases on their support. The skill of the operator is no doubt the key to the success of the procedure.

Carl O. Boucher has attempted a thumbnail sketch of all of the various concepts of occlusion in prosthodontics. The subject is so broad that some phases of these concepts are not fully developed. The fundamental ideas are expressed in simple language that can be understood by those who are not familiar with prosthetic problems and prosthetic nomenclature. This is done with the hope that a more sound dental nomenclature may be evolved.

Howard J. Merkeley describes the construction of a very complete and accurate set of pre-extraction records. The bending of a wire to fit the profile may be less accurate in its detail than a photographic record of the profile, but the suggested means for relating the pre-extraction casts to the profile wire will outweigh this disadvantage. We agree that pre-extraction records are most important and helpful. They should be made for every patient who may become edentulous.

C. A. Kennedy, Jr. lists the causes of troubles with full dentures. While there may be some oversimplification, certainly the analysis of the cause of each difficulty listed will lead to the possible means for correction of the trouble. The list could have been extended to cover other difficulties, such as those related to esthetics and phonetics.

Henry A. Collett and Dennie L. Briggs report three cases of denture-stimulated gagging. Through these they establish definite psychologic influences on the patient's reaction to dentures. The cases demonstrate that not all gagging is produced by mechanical deficiencies in dentures. The suggestion is implied that this type of gagging patient should have psychiatric treatment before dentures are made.

Henry C. Parker suggests that the dentist place himself in the position of the patient when he is attempting to have the patient accept his services. While this is good psychology, it is sound also while the decisions as to the type of service the patient should have are being made. The decisions arrived at in this manner do not need much selling. He suggests kindness and understanding. These inspire the confidence which is necessary to successful patient-dentist relations. He reports a cooperative effort on the part of dentists and physicians which is revealing the shortcomings of both professions in their attitudes toward their patients.

Niels Bjorn Jorgensen discusses the use of premedication in prosthodontics. He suggests that the discomfort some people feel during preparations for restorative work is largely fear. Pemedication can be combined with local anesthesia to eliminate this difficulty. He describes the techniques and gives the dosages of drugs for the various types of premedication which may be required by prosthodontists.

J. C. Almy Harding discusses the dangers, advantages and techniques of nutrition therapy by dentists. This is done in an interesting and informative manner. The suggestions should prove helpful to those who recognize their total responsibility to their patients. Artificial restorations alone cannot maintain dental and oral health. Adequate nutrition must be maintained after the restorations are placed. We agree that there is a need for care in advising patients in

order that they can avoid food fads and diets which are nutritionally inadequate.

Raymond L. Girardot discusses the physiologic aspects of partial denture restorations. He emphasizes the importance of a thorough and adequate diagnosis which he divides into four phases. The first and last of these are directly related to the general and oral health of the patient. The remaining teeth and the design of the various parts of the restoration are clearly demonstrated to be related to the other two phases of diagnosis. Certainly this physiologic approach to partial denture design is a vital part of the dentist's responsibility in partial denture restorations. All mechanical and engineering factors must be subservient to the biologic factors. After an excellent discussion of design based upon biologic principles, he discusses the environment of the restorations and makes some suggestions which may be open to some question. While it is essential that the mouth and the entire body remain healthy after the restorations are placed, we should never hide behind the poor health of our patients for our own biomechanical failures. Our obligation is to help the patient regain his health.

Ellsworth K. Kelly divides partial denture work into three phases and discusses the designing phase in relation to physiologic considerations. He has set up ten basic principles of design. Each of these is related to the basic physiology of the tissues involved. It is a good analysis of the partial denture problem. While some will disagree, at points, with some of his technical solutions, there will be little objection to his basic principles. His specifications for information to be supplied by the dentist to the laboratory technician are particularly noteworthy.

Clyde H. Schuyler urges that dentists give diagnosis and plan of treatment the same emphasis as physicians do. It is the most important step in any restorative work. He is correct in saying that the dentist is entitled to an adequate fee for the time spent in diagnosis. He prefers to use precision attachments for partial denture retainers for esthetic and mechanical reasons, but outlines procedures for semiprecision clasps which overcome his major objections to the ordinary clasp design. The use of the principles he follows will prove more economical to the patient in the long run than a less expensive restoration at the moment.

Austin H. Kutscher reports tests on the masking of clasp arms by acrynamel cement. The procedure would certainly improve the appearance of some clasps, but the report that the masking failed on 29 per cent of the clasps indicates that further improvement is needed.

Victor Penzer suggests a method for making fixed bridges without soldering. The pattern for the casting is made from a self-curing acrylic. It seems likely that the inaccuracy produced by the curing shrinkage of the acrylic would exceed the inaccuracy produced by soldering. Perhaps further explanation of the various means for neutralizing the shrinkage of the acrylic pattern will overcome this objection.

John P. Knowlton reports his measurements of the biting force exerted by one patient with soft-tissue-borne dentures and with implant dentures. The measurements were made with a Bimeter which is not accurately calibrated for force, but which does indicate the relative force quite well. The measurements were carried out on only one patient, which is unfortunate. The results indicate that considerably more pressure can be exerted by the patient with implant dentures than with soft-tissue-borne dentures. The conclusion that the exercise and use of the muscles of mastication, made possible by the implant dentures were responsible for the increased biting force, does not seem sound. It was apparently pain or tenderness that limited the force exerted by the patient. She was reported to have sharp ridges. In our opinion, the muscle power always exceeds the pain tolerance. Much research is needed in the field of implant dentures. Clinical observations are not adequate. This is a step in the right direction.

Jerome C. Strain recommends that the denture which supports an obturator for a cleft in the soft palate be made before the impression for the obturator is made. This is a logical suggestion since the obturator must be stabilized by the denture after it is completed. The device he suggests for the attachment of the completed obturator to the denture will eliminate a tedious and hazardous reprocessing of the denture when the obturator is processed.

—Carl O. Boucher

DENTAL TERMINOLOGY

VICTOR H. SEARS, D.D.S.

Salt Lake City, Utah

OF THE SEVERAL uses of language, that of conveying meaning is the most important, and especially is this true in the sciences. For this purpose of conveying meaning, human beings have evolved several types of languages. All of them rely on signs or words or both. Word language is more precise than sign language. Signs and words are conventions that have come by common consent to have corresponding meanings.

It is difficult for one who speaks only his mother tongue to imagine other systems that operate on different principles. For example, there are some languages, notably those of the North American Indian, that have no nouns as we understand the term. Some of the oriental languages have no verbs. Of course, with these there would be no subject and no predicate. Pictographic languages such as Chinese have no symbols to indicate separate syllables in words as we have.

The group of languages known as Indo-European is the one to which English belongs. The group includes Sanscrit, Greek, Latin, Germanic, and the Romance languages. All of them are characterized by the subject-predicate structure of nouns and verbs. In general, the noun has a root (usually a single syllable) to which may be attached other syllables, for the purpose of modifying the meaning of the root. The syllables attached to the ends of the root we call affixes.

These syllable attachments or affixes give the Indo-European languages great flexibility. Some of the tongues, such as German, use affixes entirely or almost entirely from the language itself. English, on the other hand, uses affixes from several other languages—chiefly Greek and Latin in the sciences.

This wide range of choice leads to some confusion, and especially so because quite a number of the affixes with the same meaning are taken from different languages. In this connection, there is little justification for using a Greek affix on one root and a Latin one with the same meaning on another root. Often the choice is made on the basis of euphony. But this choice of many affixes provides the users of English with more possible variations which have finer distinctions. At the same time, we must be on guard when using these attachments. For example, "ing" usually expresses the diminutive, as in "princeling" meaning a little prince, and "duckling" meaning a little duck, but "inkling" does not mean a little ink and "bungling" does not means a little bung.

Read before the Academy of Denture Prosthetics at Los Angeles, April 14, 1953.
Received for publication April 14, 1953.

The exactness of expression in a language depends largely on its flexibility, and in this English is outstanding. Perhaps the greatest authority on language is Otto Jesperson, a Dane. Although Danish is his native tongue, he chooses to write in English as the language of greatest precision.

As already indicated, an efficient device is the attaching to the roots the many available affixes. The words "affix," "prefix," and "suffix" are good examples themselves. "Affix" means fix to, "prefix" means fix in front of, and "suffix" means fix to the end. Such little signals quite efficiently convey definite distinctions if the writer or speaker knows how to use them, and if the reader or listener has the same knowledge. But, of course, it is only when their functions are known that this fine distinction is possible.

Although we find some duplications and some examples of multiple meanings, it is quite possible to make such selections that all informed persons can extract the fine shades of meaning intended. There are in English about a hundred prefixes, three-fourths of which occur fairly often in dentistry. There are even more suffixes, and it is these that seem to give us the most trouble.

A perusal of dental literature shows that some of our writers fail to respect the integrity of our linguistic conventions. Perhaps a few words of clarification about suffixes and the roots to which they are attached will make easier the adoption of your nomenclature committee's recommendations.

As already implied, there is no excuse in scientific discussions for using words contrary to their accepted meanings. If, as Shakespeare says, "A rose by any other name would smell as sweet," it would still be wrong to call it a pansy for the reason that the word "pansy" has been reserved for another flower. We cannot switch labels this way and still be explicit. We must not misbrand things.

In dentistry, we have been guilty of misbranding or switching labels. For example, we use the word "compound" in a sense that means something quite different to a chemist, or for that matter to anyone who knows the Webster dictionary. Our British cousins are more discriminating and proper. They use the term "modeling composition." "Modeling plastic" is even more appropriate. It says just what is meant. This term was adopted last year and has already gained favor among dental writers.

Another case of misbranding is the use of the term "Gothic arch tracing." Now if words mean what by common consent they are supposed to mean, this term indicates a tracing pertaining to or resembling an arch—not just any arch but such an arch as the Goths used in their architecture. It is true that by mounting a needle point on the lower baseplate in the right to left center and far enough back in the mouth, it is possible to make a tracing on a graph plate mounted on the upper baseplate which will be a reasonable facsimile of the outline of the kind of arch used by the Goths. But when the needle point is not thus mounted, the tracing, and especially when the graph plate is mounted on the lower baseplate, is misbranded if called a "Gothic arch tracing." The Goths would not like it nor be able to match the term with the thing.

"Periphery" is another of those labels that dentists use loosely. Webster gives as the first meaning: "The line bounding a rounded surface." There are some other

definitions, but not any of them can mean the denture border or the denture flange. Geometrically, periphery means "the circumference or perimeter of a circle, ellipse, or other closed curvilinear figure." It is a line—a line marking the outer boundary of a closed figure. So "peripheral border" makes little sense, and "lingual periphery" sounds like "inner outer line." "Periphery" is a fancy word that might well be dropped from prosthetic terminology.

Dropping improper terms is part of making a language more efficient. This encourages the use of newer and better terms. In the past few years aviation, radio, television, medicine, and dentistry have been adding to and refining their terms at a rapid rate. Examination will show that most of these terms are not completely new, but are made up of parts already at hand. Until we get new ideas, we can get along well enough without new terms. It is those who evolve new ideas and fit them with appropriate terms who contribute to the advance of the sciences.

Now back to something about a few of the troublesome suffixes in our literature. Three of them have about the same meaning: "al," "ar," and "ic." They mean "pertaining to." "Oral" means pertaining to the mouth and "regal" means pertaining to the king. "Consular" means pertaining to the consul and "condylar" means pertaining to the condyle. "Algebraic" means pertaining to algebra and "anatomic" means pertaining to anatomy. Logically, we could say "condylic" or even "condylal", but by common consent we use the "ar" suffix.

"Oid" means "like" or "in the form of." So we have "ovoid,, meaning in the form of an egg and "condyloid" in the form of a condyle.

It becomes a simple matter to differentiate between "condyle" which means an articular prominence on a bone, "condylar" which means pertaining to this prominence and "condyloid" which means something in the shape of this prominence.

A closely related suffix is "ous" which means "having the quality of" instead of "having the shape of." So we have "poisonous", having the quality of poison and "petrous," having the quality of rock or stone. We speak not of the "petral," the "petrar," or the "petric," but of the "petrous" portion of the temporal bone, because we want not "pertaining to" but "having the quality of." Thus with a wide choice of attached syllables we can convey fine distinctions.

To make our progress more certain, we should from time to time re-examine and refine our terms. Your committee feels that the adoption of the terms now submitted will give us better tools to work with. There is nothing final about these terms, but for the present we can put them to use and continue to work for further improvement.

1007 Tribune Telegram Bldg.
Salt Lake City, Utah

REPORT OF THE COMMITTEE ON PRINCIPLES, PRACTICES, AND NOMENCLATURE*

C. H. Schuyler, L. G. Jordan, and V. H. Sears

Committee, Academy of Denture Prosthetics

BALANCED MUSCLE TONUS is the characteristic tonic contraction of muscles that are antagonists. *Tonus* is the slight, continuous contraction which is characteristic of a muscle at rest.

Basal Seat.—The entire tissue area under the denture base, regardless of the nature of the tissues.

Cast.—The form obtained by pouring a liquid metal or other material into a mold or impression and allowing it to harden.

Denture Foundation.—That portion of the basal seat area that supports the upper or lower denture base under occlusal load.

Occluding Relation.—The jaw relation at which the opposing teeth occlude.

Rest Relation.—The relation of the mandible to the maxilla at which there exists in all of the muscles involved a state of balanced tonus. The rest relation of the mandible exists when all of the muscles involved are in a state of balanced tonus, but the degree of jaw separation in rest relation is dependent on the sagittal inclination of the head.

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*These terms were taken from the Report of the Committee on Principles, Practices, and Nomenclature of the Academy of Denture Prosthetics. The list includes only those accepted by the Academy at its meeting in Los Angeles in 1953.

THIRTY YEARS OF NONANATOMIC TEETH

VICTOR H. SEARS, D.D.S.

Salt Lake City, Utah

THE TERM "nonanatomic" as applied to artificial posterior teeth, and especially to their occlusal surfaces, means that such teeth are designed in accordance with mechanical principles rather than from the anatomic standpoint.

This report should not be considered as an effort by the writer to convince the reader that dentists should use only nonanatomic teeth in their artificial denture work. Further study and experiment will settle that question.

Quite frankly, however, the writer considers the use of natural anatomic forms for artificial dentures as an accident in dentistry. If the designing of artificial occlusal surfaces had been first undertaken by engineers from the mechanical standpoint instead of by dentists from the anatomic standpoint, nonanatomic occlusal forms would from the start have been standard.

As for just which aspects of occlusal forms are most important, that matter will require further investigation. What is here written may help tooth designers to arrive at substantial agreement.

It will be noted that one design may appear similar to another and yet be based on an entirely different concept. (Compare Figs. *A*, 5, and 9.)

This paper is divided into three parts for the convenience of readers who are interested in different aspects of the subject. The first division is a general discussion of occlusal forms for artificial dentures, the second contains illustrations of the listed forms, together with some comments, and the third (Table I) is a chronological list of the most significant forms. Throughout, there are references given for the convenience of any who may wish to explore the matter more thoroughly.

In attempting to meet best the special situation presented by the edentulous mouth, the employment of mechanical principles need not preclude entirely the incorporation of some anatomic configurations. These, however, are introduced for appearance sake.

The distinguishing characteristic of a set of nonanatomic teeth is that it should not incorporate the disadvantages of anatomic forms. Rather, it should tend to preserve supporting structures, increase denture stability, insure greater comfort to the wearer, and at the same time, cut and mash foods efficiently.

The chief disadvantage of anatomic occlusal forms is that in chewing they direct too great a proportion of the force in horizontal directions. These horizontal forces are more detrimental than similar vertical ones.

Received for publication Aug. 8, 1952.

To the extent that occlusal surfaces direct the chewing forces vertically—to that extent do they overcome the chief fault of anatomic forms. Another important advantage of special forms is that they can be made to apply the occlusal load more nearly at the center of the denture foundation. Clearly, the special forms should be used with an understanding of the mechanical principles involved. For the most part, they require special techniques differing more or less from the techniques used with anatomic forms. The forms here illustrated should be judged partly on their efficiency, but more especially on the basis of the extent to which they direct the chewing forces vertically and centralize the loading.

It is sometimes difficult, in a new development, to know exactly when the trend was started. In the present case, it seems reasonably certain that nonanatomic teeth as here considered—that is, occlusal forms designed from the mechanical standpoint for the purpose of controlling the chewing forces—came into dentistry in 1922. This report deals especially with the developments from the middle of 1922 to the middle of 1952.

It was, in fact, the original intention to deal only with this thirty-year period. However, it seems appropriate to present a few notations about the so-called anatomic as well as the nondescript tooth forms prior to this period.

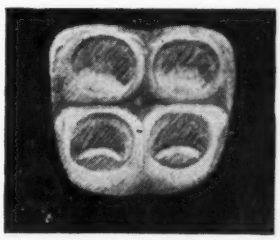

Fig. A.—Ash's Tooth—1858.

ANATOMIC AND NONDESCRIPT FORMS

Even before 1800, there were posterior teeth departing greatly from anatomic forms. It was impossible with most of the early forms to distinguish rights from lefts and uppers from lowers, and nowhere does there seem to be any thought of designing forms to meet the mechanical peculiarities of the special situation. In some instances, the forms were dictated by considerations of convenience in the manufacturing process. Not any of the early writings studied show that the tooth designers had in mind meeting the several mechanical problems from an engineering viewpoint. For the most part, the earliest occlusal forms were neither close to nature's patterns nor were they designed according to any announced principles.

In 1866 Balkwill recommended special grinding after the dentures were processed. He says: "If there seem not to be sufficient channels of clearance, enlarge them by rounding yet further the anterior inner angle and cusp of the upper molar and deepening the divisions between the cusps generally in the upper set."[1] Even to this day there is some tendency for dentists to alter anatomic forms rather than to use teeth already appropriately formed.

Perhaps the first deliberate departure of design in manufactured teeth for gaining mechanical or some other unmentioned advantage is seen in Ash's posterior teeth about 1858, and shown in Fig. A. This tooth carries "inverted cusps" suggestive of the Hall tooth of 1931. A search of the literature shows no "philosophy" behind the Ash design, and it initiated no trend.[2]

About this time or a little later Bonwill modified posterior teeth by grinding anteroposterior channels in the molars (Fig. B). This quite clearly was not for the purpose of removing interference in protrusion because he left the interference on the bicuspids. About 1916 Gritman carved the "True to Nature Posteriors" with a similar combination of the molars cleared, and the bicuspids meshing to prevent straight protrusion.

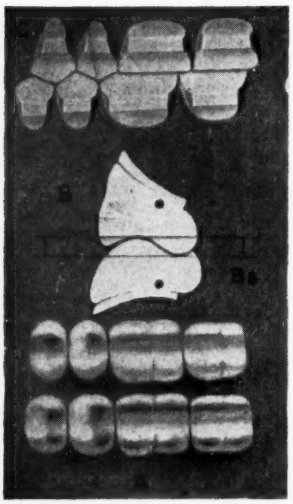

Fig. B.—Bonwill's modification.

In 1909 an attempt was made to copy natural cusp forms. In that year, the Dentists' Supply Company introduced "Twentieth Century Anatomical Bicuspids and Molars." The same company in 1914 made available a tooth form with 33 degree cusps known as "Trubyte,"[3] and most of the other manufacturers followed with teeth of similar design. This trend toward the general use of well-defined cusps continued until the 1930's when it was reversed by the more general acceptance by the profession of nonanatomic forms.

In the 1920's and well into the 1930's the tooth companies—more particularly the larger ones—tried to hold back the change. Gradually they reversed their stand until now all of the major manufacturers offer nonanatomic forms.

In the profession itself, there was an emotional block against the use of newer forms. Then, too, there was incomplete understanding of the principles involved. Some dentists tried the newer forms and failed, not realizing that the special forms required special techniques.

Some of the nonanatomic forms came from abroad, notably England, Switzerland, and Germany. However, it will be noted as with anatomic so also is it true of nonanatomic teeth that most of the advances were made in the United States.

Whereas thirty years ago the generally accepted goal of tooth designers was to

produce carvings which when removed from the porcelain oven would be close copies of natural teeth, today greater emphasis is on teeth that will be efficient without detriment to the supporting structures.

With regard to directing the chewing forces, there are three types of special occlusal surfaces: (1) those that permit easy protrusive glide, (2) those that permit easy lateral glide, and (3) those that permit easy glide in all horizontal movements. The three types are represented in the illustrations. The question of whether it is more important to provide free protrusive or free lateral glide tends to become academic with the trend toward providing freedom in all horizontal movements.

The latest development in occlusal surfaces is not one of form. Rather it is in the use of substances of different resistance to wear, this difference being for the purpose of making full use of the nonanatomic concept in preventing or correcting malrelations of the mandibular condyles.[4] As might be expected, the problem of devising the occlusal scheme has numerous phases.

We may easily overemphasize the importance of chewing efficiency. Obviously, the more efficient the dentures can be made, the kinder they are to the supporting tissues if everything else is equal. But there is some danger of increasing temporary efficiency at the expense of the integrity of the tissues.

It is also easy to overemphasize the importance of chewing tests, especially as they are usually made. Tooth designers, presumably, have certain underlying principles in mind, and for this reason they should be permitted to arrange the teeth for chewing tests or to check the arrangement before tests are made.

The last word has not yet been said about occlusal forms that will best meet the special situation presented by the edentulous mouth. During the first thirty years of development there has appeared on the average more than one new design every nine months. Others are sure to follow.

The appended list of forms, together with the illustrations and references, will give the reader a concept of past and present thinking on the subject with perhaps some ideas as to future developments.

The forty-one different designs here listed probably represent the significant ones. Some of these were several years in development before being announced, so that earlier dates than those indicated might be assigned. However, it would be practically impossible to learn exactly when each sponsor conceived his design.

For those instances in which teeth were known to be manufactured, the dates given by the manufacturers are listed. Where no company name appears in the third column the dates are taken from journal articles, books, society programs, or patent papers—whichever appears first.

Aside from a search of the literature, hundreds of letters were written in an effort to obtain exact data. Even so, the appendix may contain some unavoidable inaccuracies.

There have been other nonanatomic occlusal forms than those here listed, but most of the omitted designs are close to the anatomic forms in the respect that their opposing surfaces lock in centric occlusion.

Even today there is no general agreement respecting prosthetic occlusal forms, perhaps due largely to the absence, until recently, of a comprehensive set of specifications.[5] With such specifications now at hand, it should be possible for tooth designers to reach substantial agreeement.

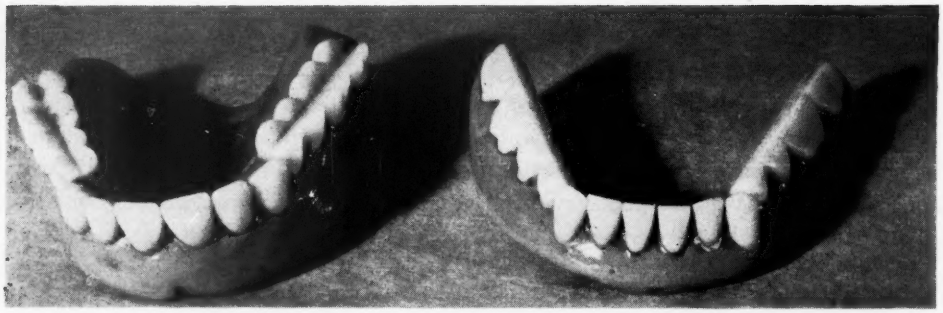

Fig. 1.—Chewing Members—1922. These early "chewing members" were ground from sets of porcelain teeth baked four teeth to the piece. They were designed to permit unlimited horizontal protrusive glide, but retained inclined planes that prevented horizontal lateral glide.[6]

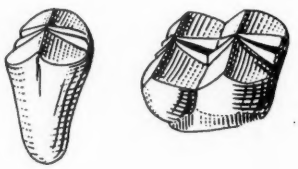

Fig. 2.—Rationalzähne—1922. It is not known whether teeth of this design were merely proposed or actually manufactured and used. Fehr apparently considered horizontal lateral glide of prime importance. Teeth of this design would prevent horizontal protrusive glide[7] (compare with Figs. B and 8).

Fig. 3.—Channel Type Posteriors—1927. These teeth were manufactured and marketed over a period of several years—discontinued when the company changed completely from porcelain to plastic. They are similar to the 1922 chewing members (see Fig. 1) except that the 1927 lower ones carry narrow occlusal tables, and the upper inclined planes are less steep.[8]

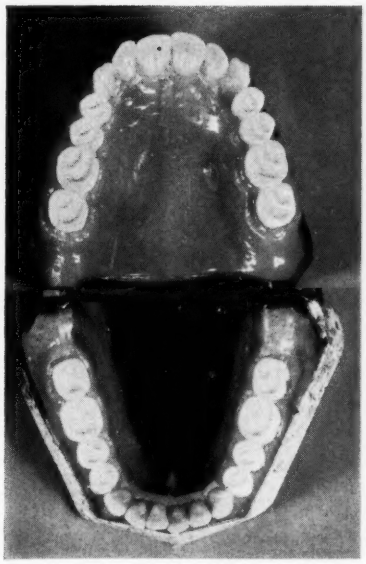

Fig. 4.

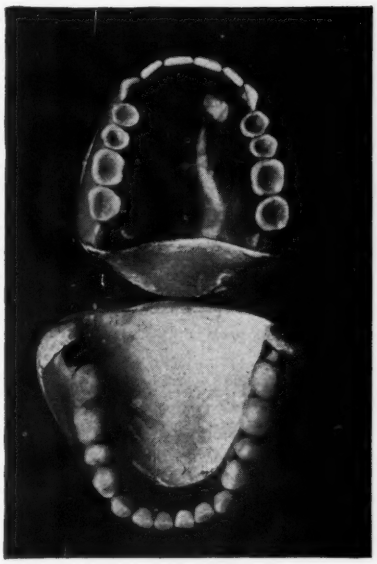

Fig. 5.

Fig. 4.—Masticators—1928 and 1939. Kelly says[9]: "These teeth, as you will observe from the picture, were so constructed as to release food as the jaw moved forward and outward and 'trap' and cut the food substance on returning to a rest position. Under this saw-like principle, the dentures were stabilized with no 'tipping' or dislodging of the upper denture."

Fig. 5.—Kuppel und Muldenzahn—1929. The lower teeth are rounded to fit loosely into the upper depressions to produce a multiple mortar and pestle effect.

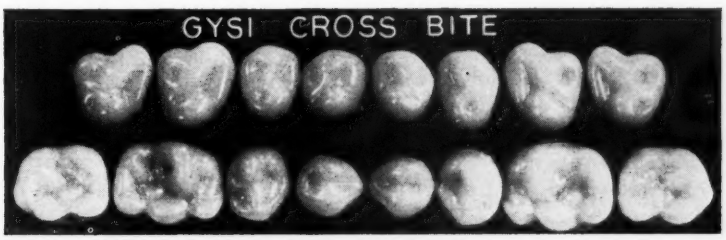

Fig. 6.—Crossbite Posteriors—1929. Before these teeth were marketed they were tested clinically. Clapp and Gysi reported: "About 60 per cent of the full dentures at the University of Zurich are better served with cross-bite forms of teeth than with normal forms."

Fig. 7.—True Kusp—1929. This tooth appears to be the first one designed to glide freely in all horizontal directions.

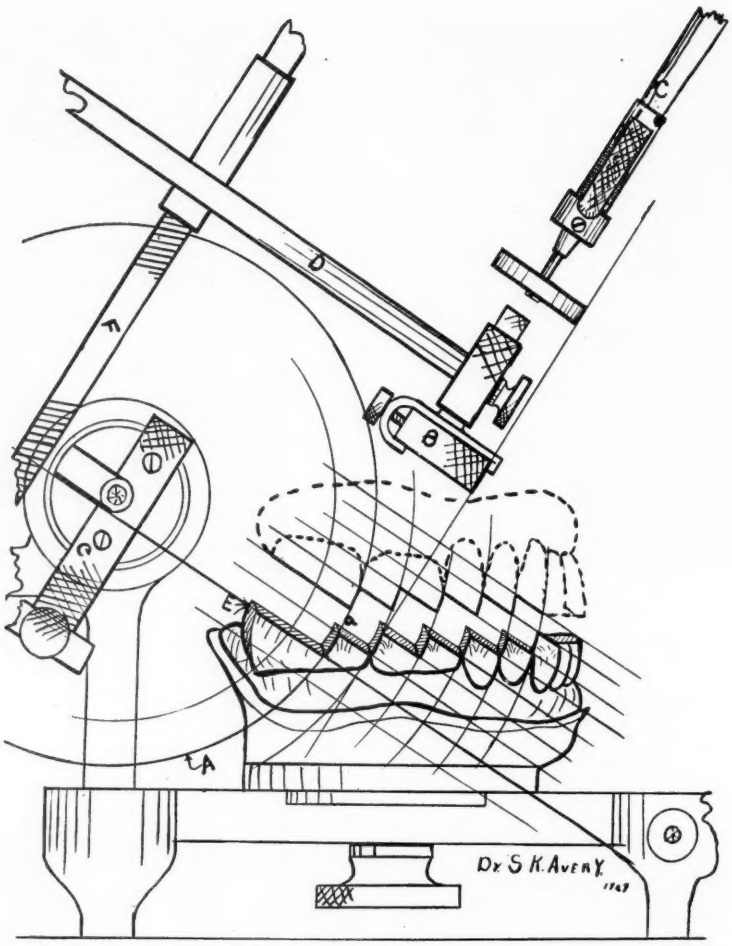

Fig. 8.—Scissor Bite Teeth—1930. With the mandible closing in centric relation the food is sheared on the mesial edges of the upper posterior teeth.[10]

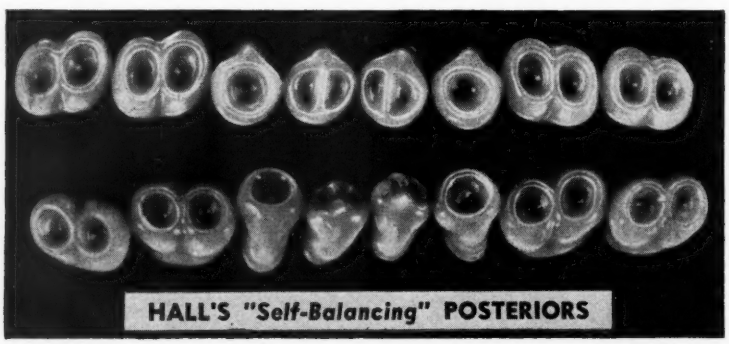

Fig. 9.—Inverted Cusp Tooth—1931. This design is formed especially to shear food. Whereas the shearing of the Avery tooth (Fig. 8) is accomplished by closing in centric relation, the Hall tooth shears best in horizontal movements.

March 2, 1937. E. L. PILKINGTON ET AL 2,072,127

ARTIFICIAL TEETH AND METHOD OF FORMING THE SAME

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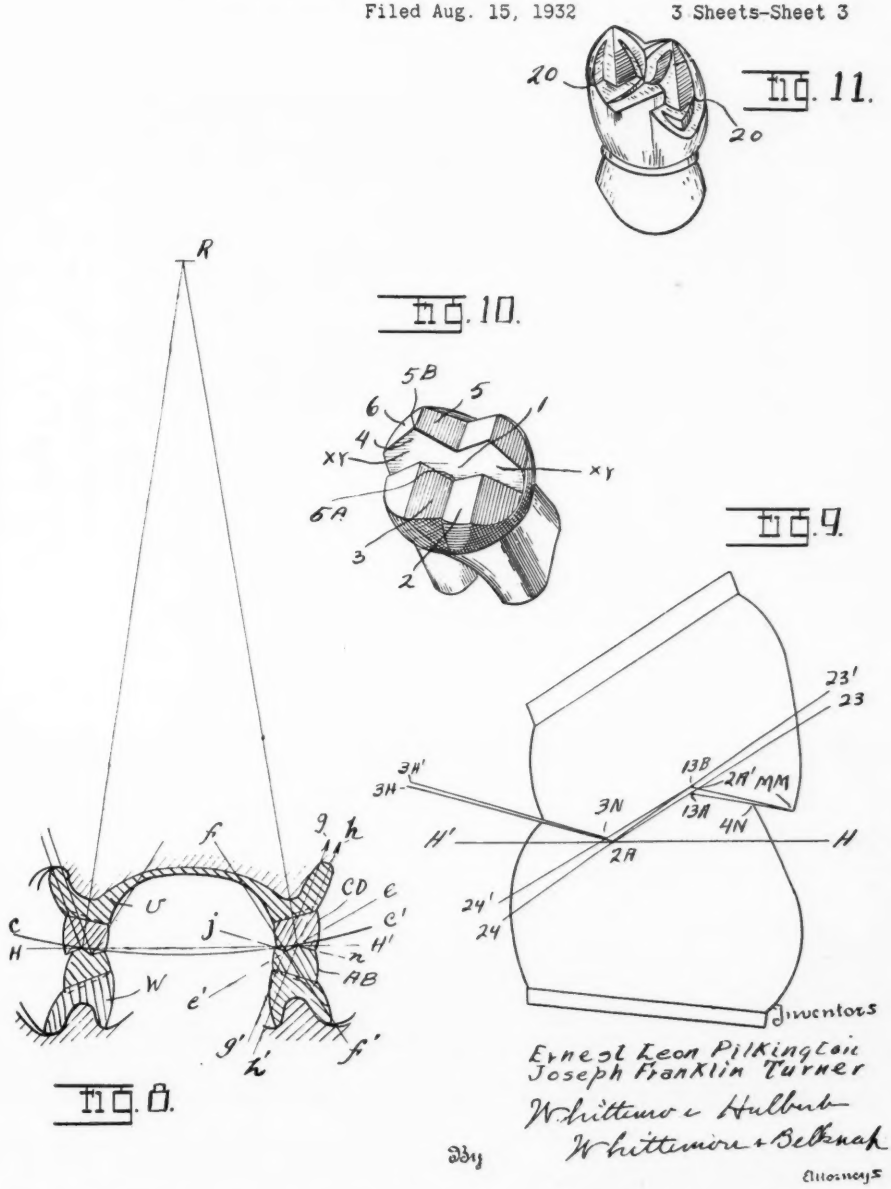


Fig. 10.—Pilkington-Turner Tooth—1932. Patent claims include, "Briefly summarized, our improved model form for artificial posterior teeth is one in which all of the cusps are of trihedral form with transverse grooves therebetween having the bucal and lingual portions in alignment and the apices of all cusps lying the surface of a sphere. A further feature of the construction is that two of the faces of each cusp of teeth on one side of the jaw are generated by a transverse movement from a center on the same side of the jaw, while the third face of the cusp is generated by a movement from a common center on the opposite side of the jaw." (Compare with Fig. 21.)

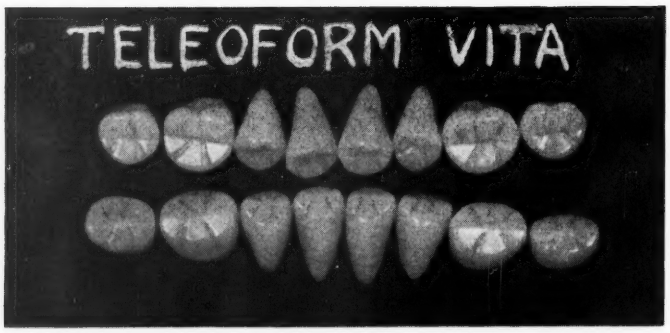


Fig. 11.—Vita Teleoform—1933. This form reverts somewhat to the idea in chewing members (see Fig. 1).

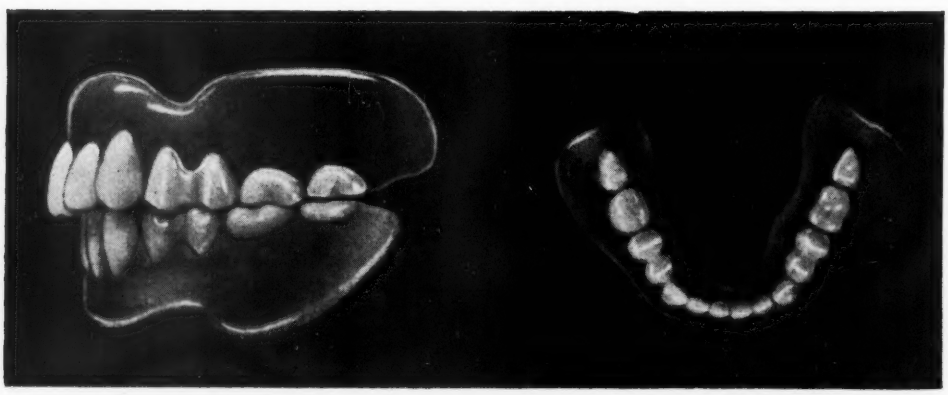


Fig. 12.—Nutec Diatorics—1934. Fish designed these teeth largely to direct the closing force favorably on the denture foundations.[11]

July 2, 1935. G. P. PHILLIPS 2,006,717

ARTIFICIAL TEETH

Filed May 18, 1934

Fig. 1

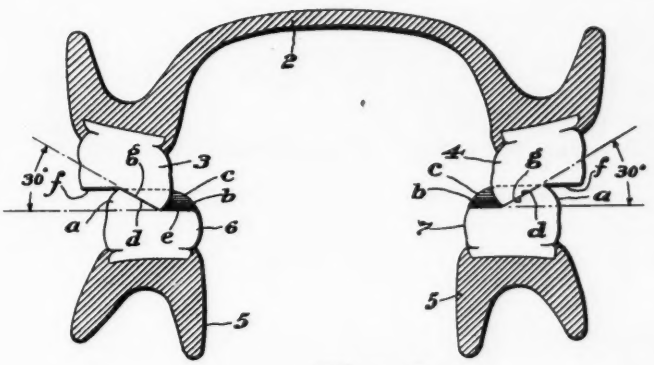


Fig. 2

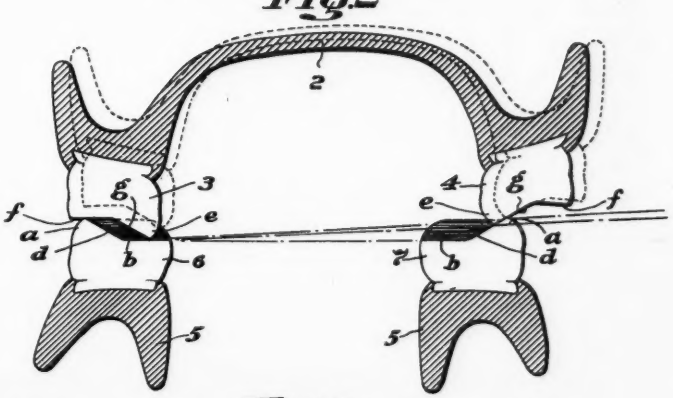


Fig. 3a.

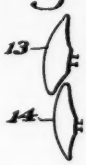
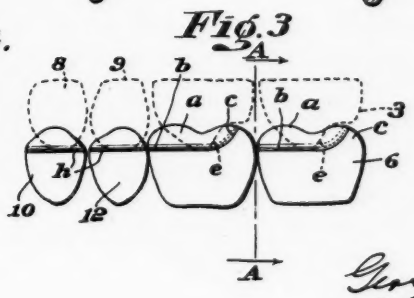


Fig. 3



INVENTOR:
George P. Phillips,
By his Attorney,
J. H. McCurdy,

Fig. 13.—Phillips Tooth—1934. Patent claims include: "A set of artificial teeth in which the lower molars have buccal cusps and are provided with low, approximately horizontal occlusal surfaces instead of the usual mesio-lingual cusps and have disto-lingual cusps, and the upper molars having mesio-palatal cusps and approximately horizontal occlusal surfaces opposed to the cusps of the lower molars."

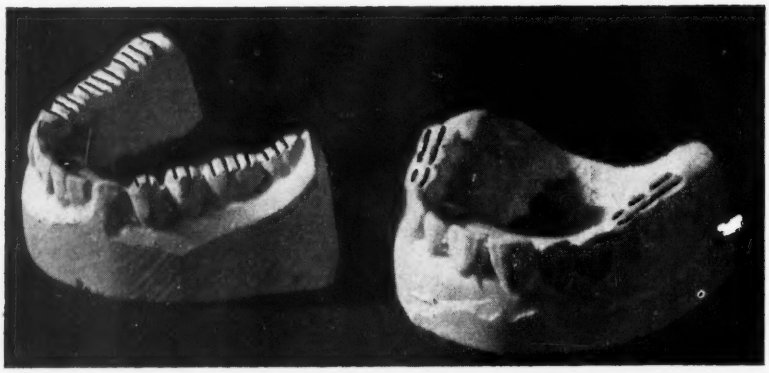


Fig. 14.—Chopping Block Teeth—1934. This tooth was designed for both cutting and mashing.

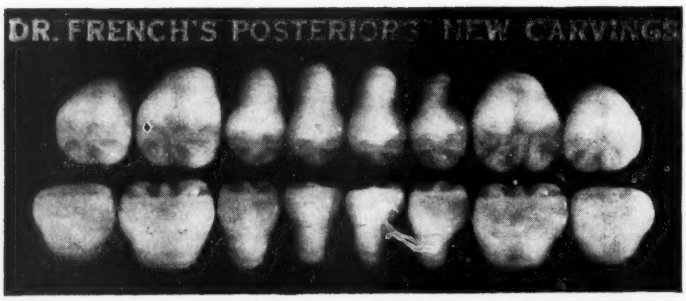


Fig. 15.—Modified Posteriors—1935. The French design is similar to the Channel Type (see Fig. 3) except that the upper teeth are more nearly flat, and the lower ones carry wider occlusal tables.

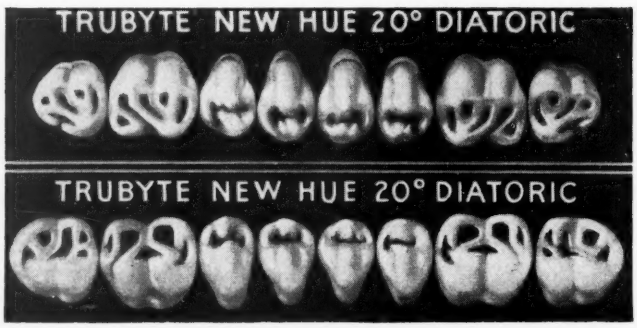


Fig. 16.—Trubyte 20 Degree Posteriors—1935. This design carries Gysi's name. Although nonanatomic in form, the forces are directed in very much the same directions as with anatomic forms.

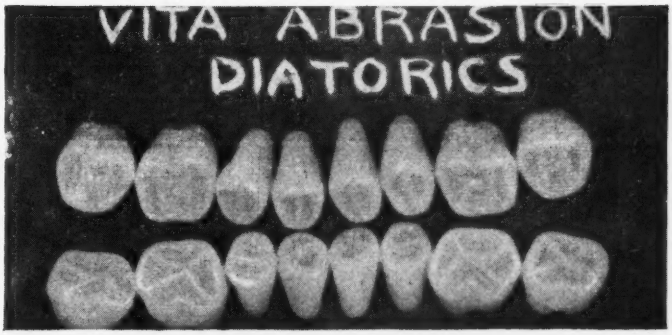


Fig. 17.—Vita Abrasion—1936. Although not clearly shown in this illustration, the upper teeth are cupped out to form a mesiodistal trough curving evenly from buccal to lingual. It may be discovered that this type of "cusp height" is better than that in a tooth with buccal and lingual planes. (Compare with Fig. 5.)

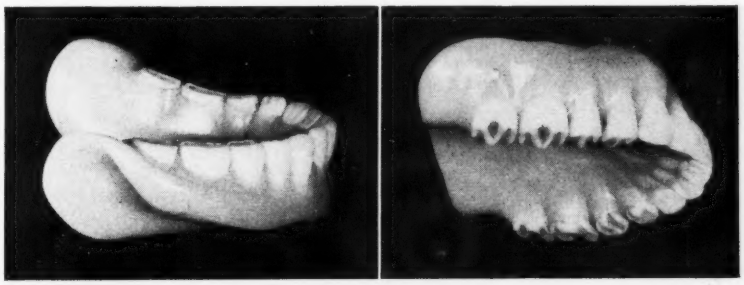


Fig. 18.—Cross Blade Porcelain—1937. In this design the cutting edges cross one another at a right angle.[12]

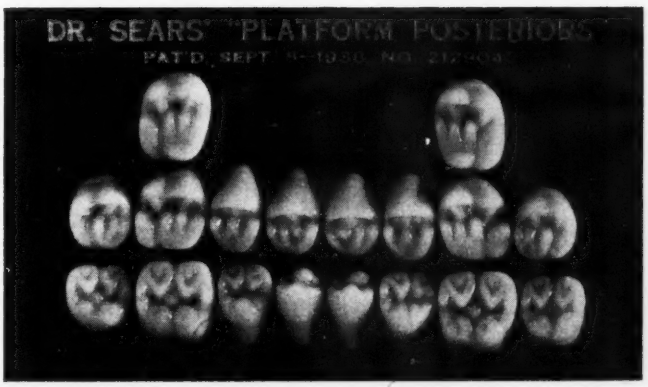


Fig. 19.—Platform Posteriors—1938. The aim of this design was to incorporate previous improvements over anatomic forms such as (1) providing freedom of movement in all horizontal directions, (2) centralizing the occlusal load, and (3) restricting the total occlusal area in order to reduce the force needed in chewing.[18]

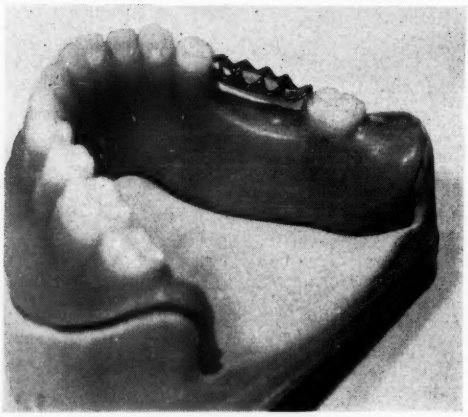


Fig. 20.—Chewers—1938. These metal "chewers" occlude against flat porcelain upper teeth. They are usually provided with free escapes for the food which has been cut. Some patients object to the opening on the lingual side which can be closed with denture base material.

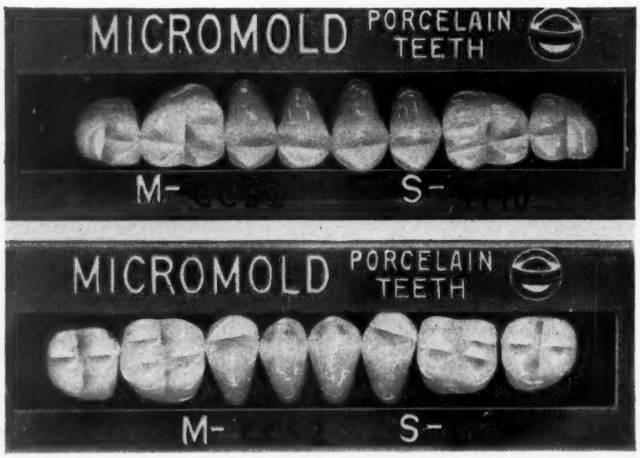


Fig. 21.—The Curved Cusp—1939. Pyramydal cusps of 25-degree inclination are designed to glide to right and left sides in arcs around right and left condyles.[14]

Fig. 22.—Table Posteriors—1939. Table posteriors are similar to "Geometric Posteriors" (see Fig. 30).

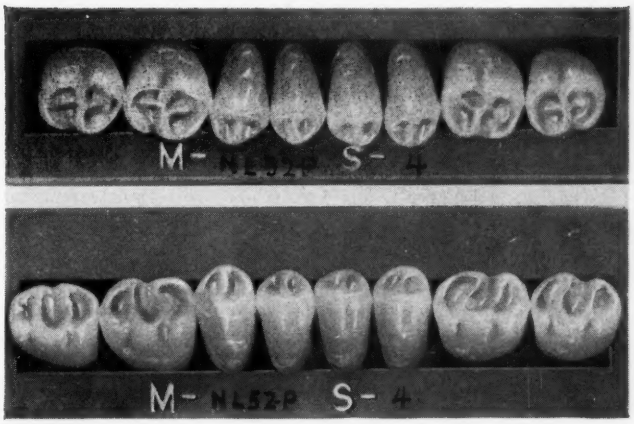


Fig. 23.—Non Lock—1939. These were carved with the idea of more or less simulating anatomic appearance without introducing elevations which might lock the occlusion.

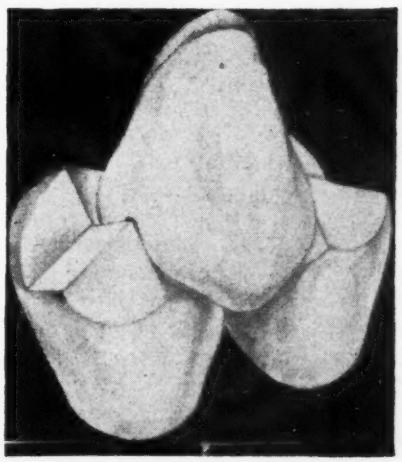


Fig. 24.—Chewers—1940. This tooth locks against all horizontal glide. It is designed for chopping and its efficiency depends on the sharp cusps. Klicka claims these advantages: "1. Bite better, 2. No spot grinding, 3. During retirement of patient while sleeping no excursions are permissible and possibly this prevents the disturbances in the temporo-mandibular joints. Restful sleep and no pain, headaches or humming in ears, and stuffing of the eustachian tube."[15]

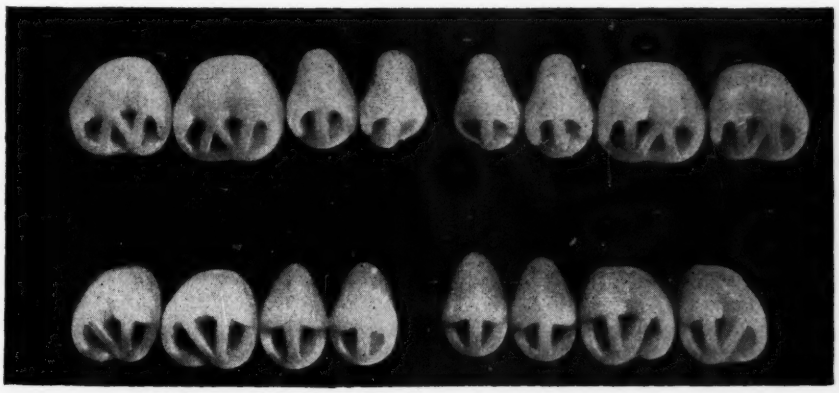


Fig. 25.—Denta Pearl Zeros—1941. These are essentially flat teeth with deep grooves.

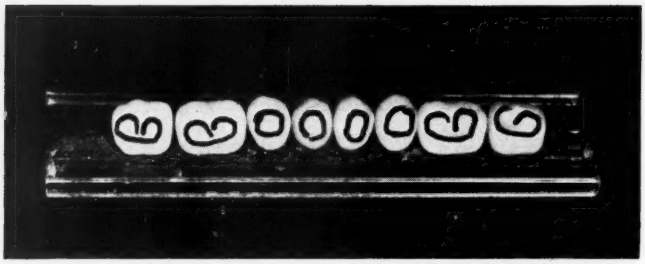


Fig. 26.—Metal Inserts—1942. Since Vincent has not written any journal articles on the subject, his explanation is quoted here, "In my apparently original combination of procelain teeth on the mandibular denture opposing maxillary all plastic teeth with stainless steel in the first and second bicuspids and first molars, and only plastic for the second molar teeth exhibits the following advantages: (1) It minimizes occlusal sounds. (2) The self clearing action exhibited through the facets of wear has the ability to harmonize protrusive condylar guidance in the second molar region with the vertical and horizontal incisal overlap. (3) It has been found that sharp porcelain edges chip easily. Stainless steel strips do not. They are thinner so they will penetrate a given food bolus with less effort and more efficiency if sufficiently cleared of plastic. (4) The molar blocks of the maxillary denture have a slight rise bucco-lingually carved in the occlusal surface.

"In as much as there is generally some condylar guidance in the lateral movements of the jaw, I have found that any prominence of plastic buccal to the stainless steel inserts that might possibly interfere with condylar harmony is very quickly ground off by the opposing mandibular French's posterior porcelain teeth. The main thought is not to have more guidance established in the tooth form than the condylar joint might influence in the molar and bicuspid region.

"(5) It is interesting to visualize 'the second molar point' (the distal occlusal angle of the lower second molar) functioning without guidance from opposing teeth. In protrusive, it moves downward and forward while the 'incisor point' (mesial incisal angle of the lower central incisor) moves upward and forward due to muscle tension. It would seem obvious then that a set of dentures with cusps and an incisal rise due to a vertical overlap anteriorly are arbitrarily creating tooth guidances that are contrary to the natural uninhibited movements of the mandibular jaw. When we make any kind of dentures, anatomic or non-anatomic, we introduce into the patient's mouth appliances that arbitrarily guide the jaw into certain positions. Therefore the least amount of guidance introduced, the less trauma there will be to the underlying supporting tissues. Some of my dentures that have been in service for six month to ten year intervals exhibit facets of wear that no articulator could possibly reproduce.

"(6) In the molar blocks which we make, the second molar contains no stainless steel. It is arbitrarily cut up twelve to fifteen degrees from a flat occusal plane. At the time of the wax set up try-in, the lower opposing second molar in porcelain is placed slightly higher in soft wax and the patient is instructed to close in centric position. Next he is instructed to bring the anterior teeth forward to the functioning incisal position. This one protrusive movement automatically harmonizes the definite condylar guidance with the arbitrary second molar angle, and with the arbitrary incisal relation. This then is harmony for at least a positional relationship. (A checkbite only records a positional relation for the articulator.) With this procedure, we are using the mouth for an articulator. In the finished denture, the intermediate movements are ground into balance by the lower, more abrasive porcelain teeth. But the abrasive action of the lower denture teeth do not create excessive wear because the stainless steel inserts act as stops. This type of action, even under resorptive closure, eventually places the heaviest chewing stresses in the antero-posterior "geographical center" of the denture where the chewing stress can best be absorbed with a minimum amount of tipping of the denture base. This self-clearing feature keeps the dentures from hitting heavy anteriorly or posteriorly. Clinically the chair time for adjustments is dramatically reduced.

"(7) If an original horizontal overlap for a given centric relation is approximately 1.5 mm., but due to resorptive closure and wear, definite facets of wear are created on the lingual surface of the maxillary anteriors, an increase in the vertical dimension is indicated. These guides for reestablishing the original horizontal overlap in rebasing and relining becomes a much less hazardous operation with nonanatomic tooth forms than it would be with eustomary anatomic tooth forms."[16]

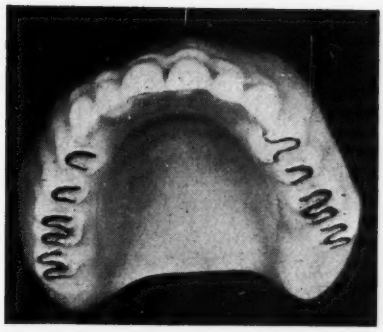


Fig. 27.—Cross Blade Metal—1942. This is one of the variations used and described by Blanchard.[12]

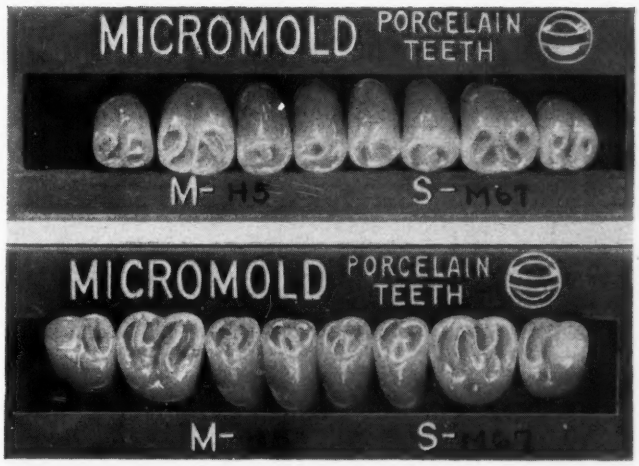


Fig. 28.—Sharp Occlusal—1942. Hardy made this design for both porcelain and plastic and describes them in his article.[17]

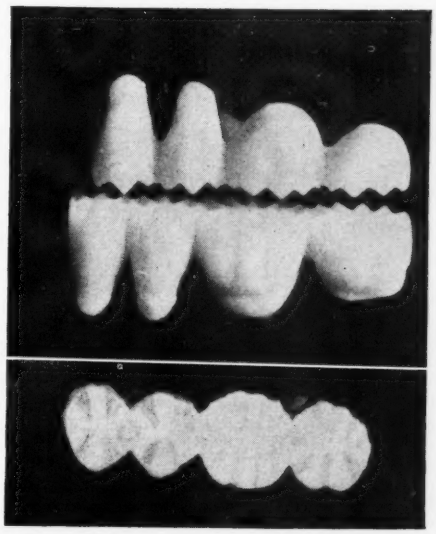


Fig. 29.—Posterior Tooth Blocks—1945. Designed for efficient shredding. Kurth describes them as follows: "The four posterior teeth are carved in one block with no interdigitating cusps, the carvings as shown are spillways. They are carved to a flat plane from a side view, eliminating the curve of Spee. In the frontal view, the occlusal surface depicts a reverse or anti-Monson curve."[18]

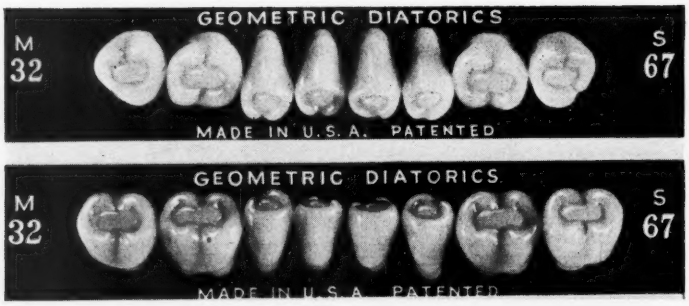


Fig. 30.—Geometric Diatorics—1947. These teeth are similar to the 1939 design (see Fig. 22).

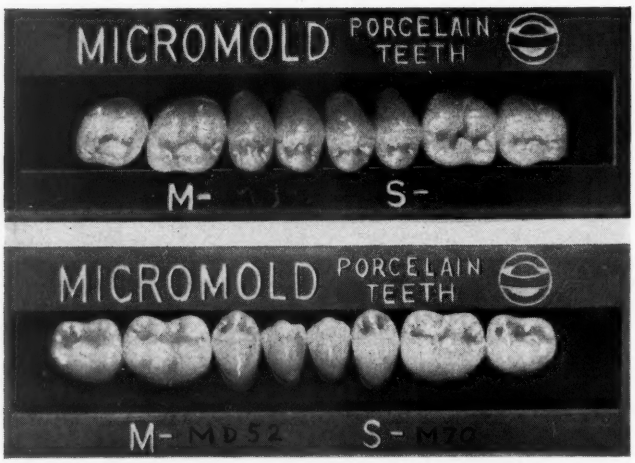


Fig. 31.—Micro-Denture-Porcelain—1949. Although a cusped tooth, this is designed to reduce the amount of horizontal force on the denture foundations.

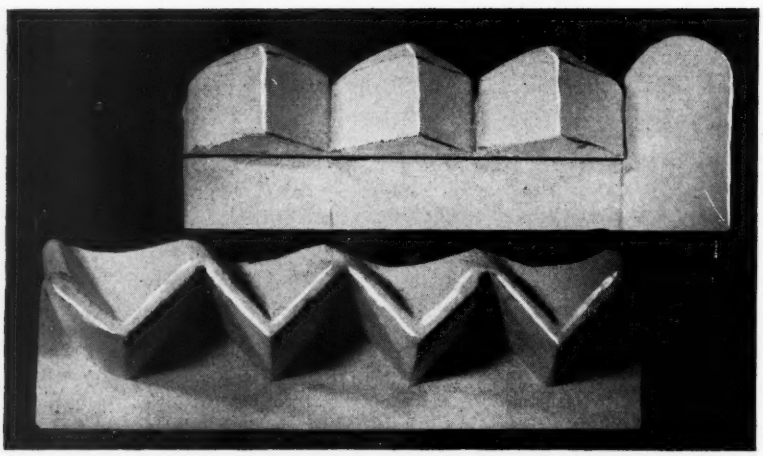


Fig. 32.—Chewers—1949. Teeth for the left side. This latest Klicka design is even more radical than his first. The upper molar plane is set to hold the mandible in slight protrusion during chewing.

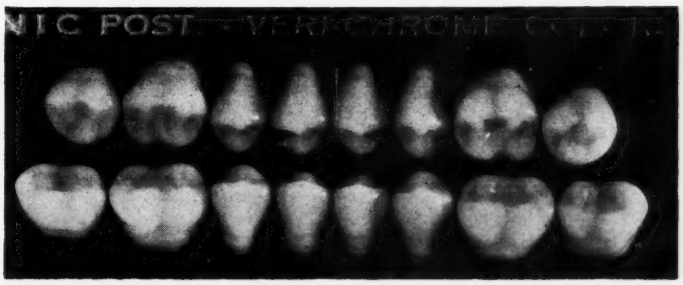


Fig. 33.—N I C —1949. "Non-interfering cusp" teeth are designed to look like anatomic teeth but to function without occlusal interference when arranged correctly.

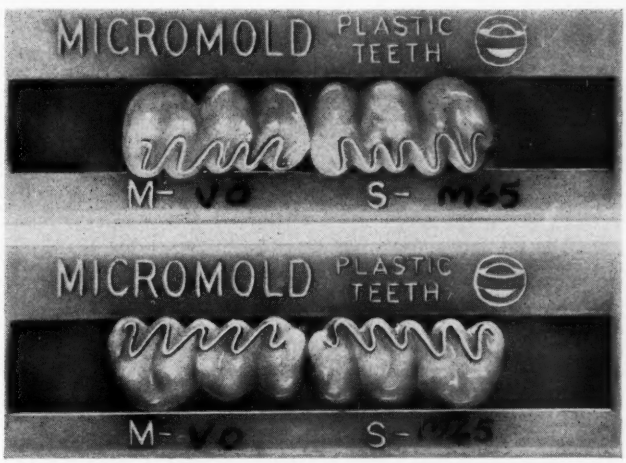


Fig. 34.—Vitallium Metal Inserts—1950. The metal inserts are so placed that there is a crossing of blades for shearing efficiency.

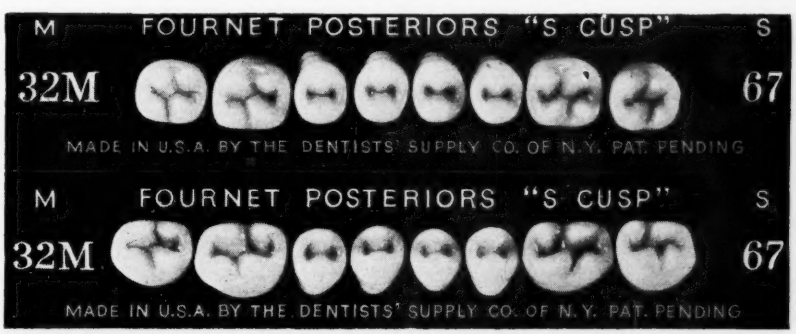
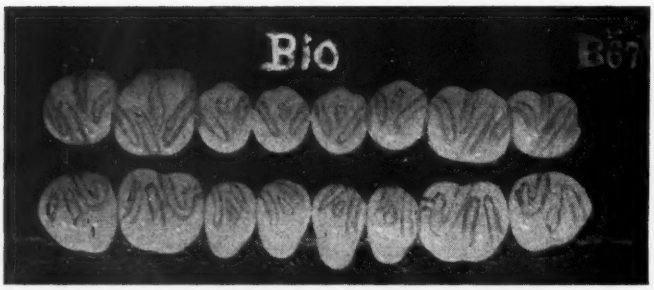

M FOURNET POSTERIORS "S CUSP" S
32M 67
MADE IN U.S.A. BY THE DENTISTS' SUPPLY CO. OF N.Y. PAT. PENDING
M FOURNET POSTERIORS "S CUSP" S
32M 67
MADE IN U.S.A. BY THE DENTISTS' SUPPLY CO. OF N.Y. PAT. PENDING

Fig. 35.—Fournet Posteriors—1950. These teeth are claimed to be efficient for chewing. Described: "They are narrow bucco-lingually, and the cusps are reduced to a common height. They have deep grooves which act as escapeways for food."[19]

Fig. 36.—Shear Kusp—1951. These were the first of the cross-linked co-polymer plastic teeth. The development of this type of plastic by Myerson has pretty well overcome the objections levelled at the previous plastic teeth. Shear Kusp teeth are supplied optionally with "flat" biscuspids to permit the protrusive glide. The Myerson Tooth Corporation issues a booklet describing their advantages and use.[20]



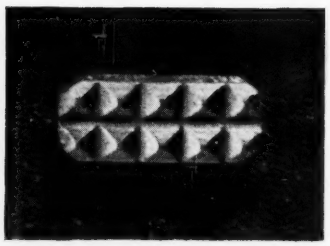


Fig. 37.—Bio—1951. These are flat occlusal surfaces with distinctive markings.

Fig. 38.—Masticators—1951. This is a metal block carrying pyramids, the points of which are intended to make contact with an opposing flat surface.

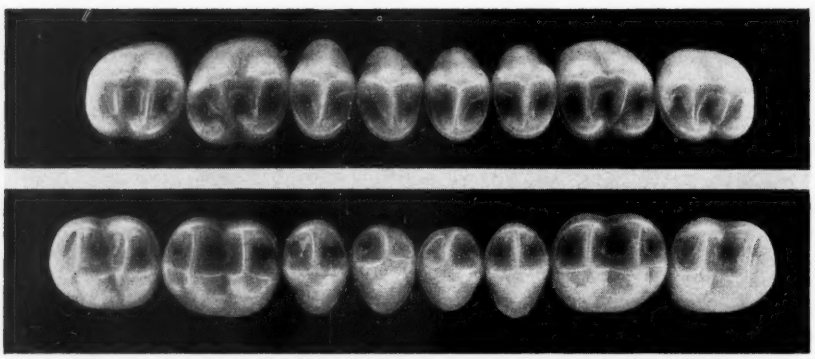


Fig. 39.—Justiform—1952. Here is another attempt to produce natural appearing teeth that will chew food efficiently without too great stress on the denture supporting structures. H. D. Justi and Son, Incorporated, issues a booklet describing their advantages and use.[21]

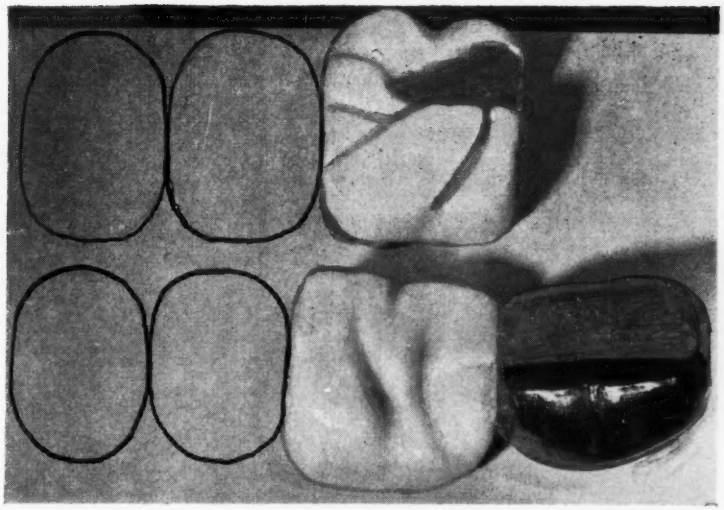


Fig. 40.—Design 52—1952. The essential departure in this design is the placing of the lateral balancing unit on the buccal part of the lower second molar where it will be out of the way of the tongue instead of on the lingual part of the upper first molar as was done with Platform Posteriors (see Fig. 19). The bicuspids are represented by mere outlines as the three molars are the teeth of special design. The working occlusal, subocclusal, and balancing units are indicated in the three different shades.

The molars are made of porcelain to act as stops[22] while the teeth anterior to these are of plastic to permit greater wear so that any excess pressure developing on the anterior part of the occlusal scheme will be reduced automatically.

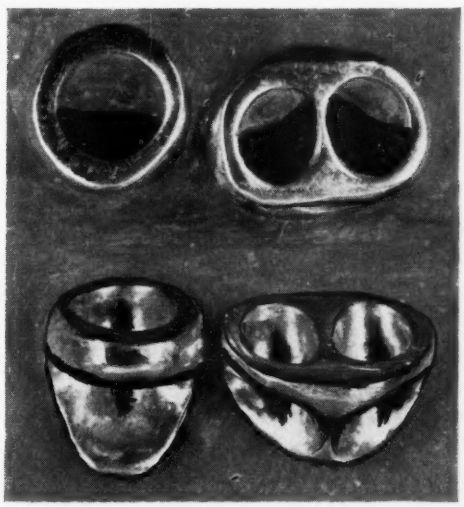


Fig. 41.—I. L. Cook—1952. The lower second biscuspids and first molars are cast in stainless steel to occlude with upper porcelain surfaces. Anterior to these, the designer recommends plastic teeth. (Compare Figs. 9 and 20.) In the Cook design, the food forced into the wells is forced out on the buccal sides of the teeth. Quoting from a letter of explanation[23]: "I have found that with slight use the porcelain teeth abrade the metal teeth so the cutting and shearing action is very excellent and produces a cud that is finely cut up with no more than twenty chews. Because of the fact that these metal teeth *cut* and shear instead of *crush* and shear reduces the biting pressure required to masticate food at less than one-third."

TABLE I. NONANATOMIC TOOTH FORMS

Date of first manufacture if known; If manufacture is not known, date is first published notice.

	DATE	NAME	DESIGNER	MANUFACTURER
1.	1922	Chewing Members (Porcelain)	Victor H. Sears	
2.	1922	Rationalzähne (Porcelain)	C. U. Fehr	
3.	1927	Channel Type Posteriors (Porcelain)	Victor H. Sears	H. D. Justi & Son, Inc.
4.	1928	Masticators (Porcelain 1928 Plastic 1939)	E. Byron Kelly	
5.	1929	Kuppel und Muldenzahn (Porcelain)	Herman Schroeder	
6.	1929	Crossbite Posteriors (Porcelain)	Alfred Gysi	Dentists' Supply Company
7.	1929	True Kusp (Porcelain)	Simon Myerson	Myerson Tooth Corporation
8.	1930	Scissor Bite Teeth (Porcelain)	B. W. Avery & S. K. Avery	
9.	1931	Inverted Cusp Tooth (Porcelain)	Rupert E. Hall	Coe Laboratories
10.	1932	Pilkington-Turner Tooth (Porcelain)	E. L. Pilkington & J. F. Turner	Dentists' Supply Company, 1952
11.	1933	Vita Teleoform (Porcelain)	C. Hiltebrandt	Vita Zahnfabrik
12.	1934	Nutec Diatorics (Porcelain)	E. W. Fish	Dental Manufacturing Co.
13.	1934	Phillips Tooth (Porcelain)	G. P. Phillips	
14.	1934	Chopping Block Teeth (Porcelain)	A. Alfred Nelson	Self
15.	1935	Modified Posteriors (Porcelain)	Felix A. French	Universal Dental Company
16.	1935	Trubyte 20 Degree Posteriors (Porcelain)	Alfred Gysi	Dentists' Supply Company
17.	1936	Vita Abrasion (Porcelain)	C. Hiltebrandt	Vita Zahnfabrik
18.	1937	Cross Blade Porcelain	C. H. Blanchard	
19.	1938	Platform Posteriors (Porcelain)	Victor H. Sears	Universal Dental Company
20.	1938	Chewers (Metal)	Charles Wharton	Austenal Laboratories, Inc.
21.	1939	The Curved Cusp (Porcelain)	H. F. McGrane	Austenal Laboratories, Inc.
22.	1939	Table Posteriors (Porcelain)	J. B. La Due & J. A. Saffir	H. D. Justi & Son, Inc.
23.	1939	Non Lock (Porcelain)	Merrill G. Swenson	Austenal Laboratories, Inc.
24.	1940	Chewers (Porcelain)	Rudolph Klicka	
25.	1941	Denta Pearl Zeros (Plastic)		H. D. Justi & Son, Inc.
26.	1942	Metal Inserts (Metal-Porcelain)	John T. Vincent	
27.	1942	Cross Blade Metal (Metal & Plastic)	C. H. Blanchard	
28.	1942	Sharp Occlusal (Porcelain, also Plastic)	I. R. Hardy	Austenal Laboratories, Inc.
29.	1945	Posterior Tooth Blocks (Porcelain)	L. E. Kurth	

TABLE I. (Cont'd)

DATE	NAME	DESIGN	MANUFACTURER
30. 1947	Geometric Diatorics (Porcelain)	J. B. La Due and J. A. Saffir	Dentists' Supply Company
31. 1949	Micro-Denture-Porcelain (Porcelain)	Ralph L. Folsom	Austenal Laboratories, Inc.
32. 1949	Chewers (Porcelain)	Rudolph Klicka	
33. 1949	N I C (Porcelain)		Universal Dental Company
34. 1950	Vitallium Metal Inserts (Metal and Plastic)	I. R. Hardy	Austenal Laboratories, Inc.
35. 1950	Fournet Posteriors (Porcelain)	Sidney S. Fournet	Dentists' Supply Company
36. 1951	Shear Kusp (Plastic)	Simon Myerson	Myerson Tooth Corporation
37. 1951	Bio (Porcelain)	M. M. De Van	
38. 1951	Masticators (Metal)	G. W. Grant	Self
39. 1952	Justiform (Plastic)		H. D. Justi & Son, Inc.
40. 1952	Design 52 (Porcelain & Plastic)	Victor H. Sears	
41. 1952	Cook (Porcelain and Metal)	I. L. Cook	Coe Laboratories

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THE FACE-BOW, ITS SIGNIFICANCE AND APPLICATION

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Stockholm, Sweden

IF WE WISH to know something about the face-bow, how this instrument is used, and the significance of its application, I feel that a short historical survey of the ideas connected with these problems, and of the working methods and instruments that they have given rise to, will afford a good picture of the salient features that are important to remember in this connection.

About ninety years ago it began to be realized that in full denture prosthesis, it was important to mount the plaster casts in the articulator in a given positional relation to the condylar mechanism. According to Bonwill, the distance from the center of each condyle to the median incisal point of the lower teeth is 10 cm. He used this standard for mounting his casts in the articulator. Bonwill did not mention, however, at what level below the condylar mechanisms the occlusal plane should be situated. It appears that he mounted his casts with the occlusal plane in a horizontal position about midway between the upper and lower part of the articulator. It is evident that he considered this quite satisfactory. Bonwill had reached these conclusions about 1860 (Fig. 1).

Balkwill, an English dentist, devised methods that were an improvement on Bonwill's. Though these investigators were contemporaries, it is probable that they never heard of one another. In 1866 Balkwill demonstrated an apparatus with which he could measure the angle formed by the occlusal plane of the teeth, and a plane passing through the lines extending from the condyles to the incisal line of the lower teeth. According to his investigations, this angle varied from 22 degrees to 30 degrees. He could also determine approximately the distance from each condyle to "the front of the gums." These were the measurements that he subsequently used for mounting his plaster casts in an apparatus that probably corresponded to an articulator. Unfortunately, I have not been able to obtain any illustrations of his instruments (Fig. 2).

It appears that the position of Balkwill's casts in the articulator was much more correct than that which was obtained by Bonwill's method. Balkwill's theories were forgotten, however, and it was only at the beginning of this century that they were rediscovered.

Another apparatus for localizing the plaster casts in the articulator was constructed by Hayes in the 1880's. This apparatus was known as the "Caliper." It did not, however, represent any particular progress in the solution of these problems. Only the median incisal point was localized in relation to its distance from

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the two condyles. There was no control of the proper orientation of the occlusal plane (Fig. 3).

Walker invented the "Clinometer," a new type of instrument with which it would have been possible to obtain a relatively good value for the position of the lower cast in relation to the condylar mechanism, better than with all the previous apparatus, but, as Fig. 4 shows, it was an exceedingly complicated apparatus. Walker only used his instrument, however, for measuring the inclination of the condyle path; and he appears not to have utilized the possibilities of the instrument as a face-bow. He mounted his casts in the articulator in accordance with Bonwill's method. The Clinometer was constructed in the 1890's.

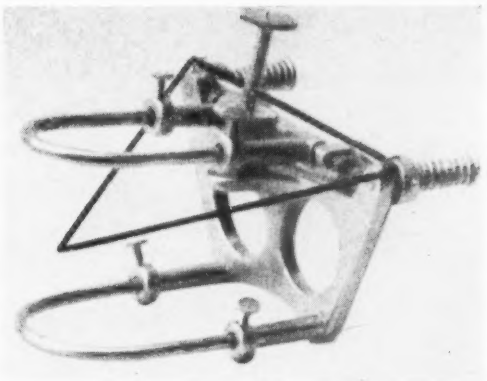

Fig. 1.—An improved model, but in principle a typical Bonwill articulator, with his 10 cm. (4 inch) equilateral triangle. When the occlusal plane of a case is placed midway between the upper and lower parts of the articulator, the plane is situated only about 2 cm. below the level of the condyles. (Compare Fig. 2.) (From Gysi.)

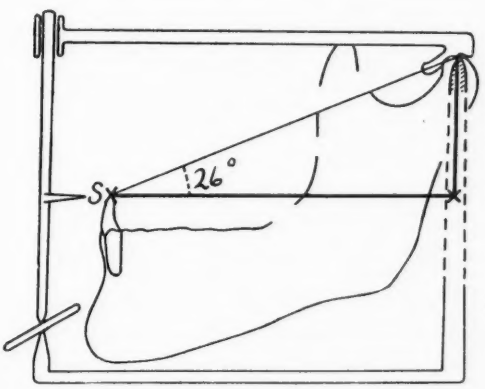

Fig. 2.—The figure shows, inter alia, that an average "Balkwill angle" of 26 degrees corresponds to a distance of 3.5 cm. between the occlusal plane and a plane at the level of the condylar elements, which is thus nearly double the difference in level in Bonwill's articulator. (From Gysi.)

A little later, at about the turn of the century, Gysi constructed an instrument for registering the condyle path. Gysi, however, also employed his apparatus as a face-bow. There are several modifications of this instrument, but in principle these are all alike (Fig. 5).

At approximately the same time as Gysi introduced his apparatus, Snow constructed an instrument which has become the prototype for all the later constructors

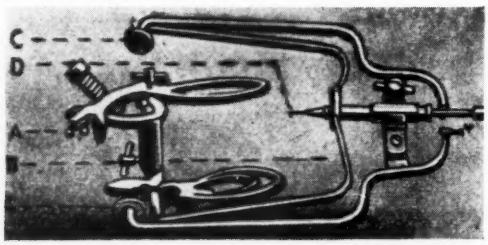

Fig. 3.—Hayes' "Caliper" and articulator. (From Müller.)

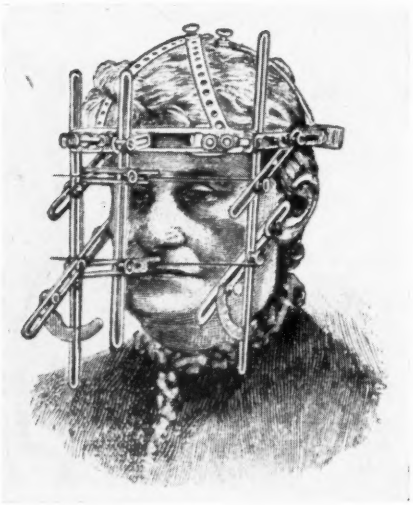

Fig. 4.—Walker's Clinometer. A bite-fork leads from the outer apparatus into the lower occlusion rim, and a detail of the apparatus also indicates the position of one of the condyles. In this way, the lower cast could be mounted in the articulator quite accurately. (From Müller.)

of face-bows. *We are justified in stating that Snow's face-bow—in spite of its very simple construction—was epoch-making in prosthetic dentistry.* Since the introduction of Snow's apparatus, no fundamental changes have been made in the face-bow. Snow determined the position of the plaster casts in the articulator, not only with regard to the distance of the median incisal point from the condyles, but all the other points on the occlusion plane were given their correct position in relation to the condyles (Fig. 6).

However, the whole problem was not solved. It was also important to ascertain at what level in the articulator the occlusal plane should be placed. For this purpose, an average level has been indicated in many articulators. In Hanau's articulator, this is marked by means of a groove in the incisal pin. If, in a full denture case, the border of the upper occlusion rim is placed on a level with this

Fig. 5.—Gysi's modern registrator of the condyle paths—and also face-bow. The drawing lead, which is seen in the condyle area, reproduces the condyle path on a cardboard disc. The apparatus is supported by a bite-fork in the *lower* bite rim. (From Swenson.)

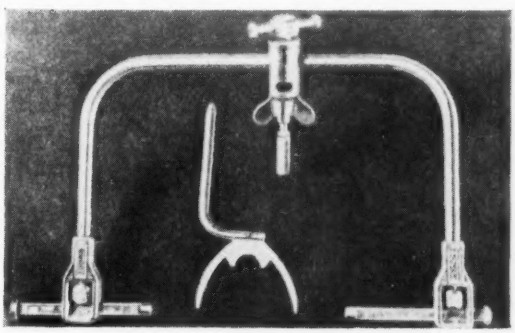

Fig. 6.—Modern face-bow according to Hanau. In principle, this face-bow is similar to Snow's, but technically it is an improvement.

groove, the occlusal plane will be about 3.5 cm. below a horizontal plane passing through the intercondylar shaft. This is, in fact, Balkwill's old average-value position. But in this way, individual deviations which may naturally occur were not taken into consideration. Snow attempted to give the occlusal plane an individual position also in this third dimension; and in order to achieve this he set

about as follows. He fixed his bite-fork in the upper occlusion rim in such a way that the handle, when the rim was placed in the patient's mouth, was parallel with a plane extending from the bottom of the glenoid fossa and passing through the anterior nasal spine. This plane cannot be determined directly on a living person; but it approximately corresponds with a line drawn from the upper part

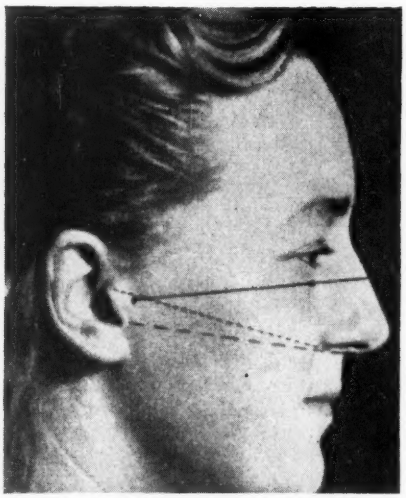

Fig. 7.—The line from the upper part of the tragus indicates what is known as Camper's or Bromell's plane. The line from the lower part of the tragus corresponds with Gysi's "protetische Ebene", and the continuous line represents the orbital plane (the Frankfort plane.) (From Beyron.)

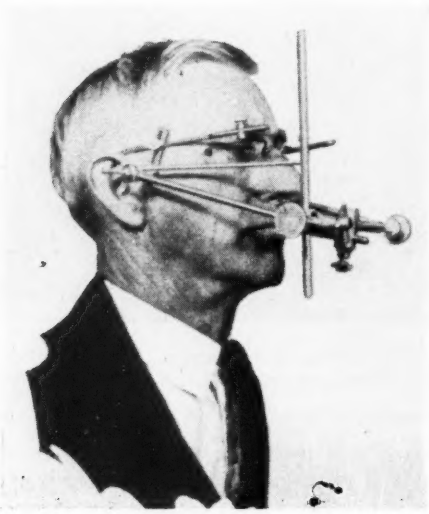

Fig. 8.—The adjustment of Wadsworth's face-bow. This shows the T-shaped equipment which is attached to the face-bow. One of its shanks rests on the rod that is fixed at the condyle point (the condyle rod). (From Wadsworth.)

of the tragus to the lower edge of the nostril. In American literature, this plane is known as the Bromell plane, in Europe as the Camper plane. Snow then placed the bite-fork horizontally when the casts were mounted in the articulator.

Another similar orientation plane was indicated by Gysi and was termed by him "protetische Ebene" (the prosthetic plane) (Fig. 7). Wadsworth employed a different plane, which extends from the condyle area and runs at right angles to a line that connects the most prominent points of the chin and forehead (Fig. 8).

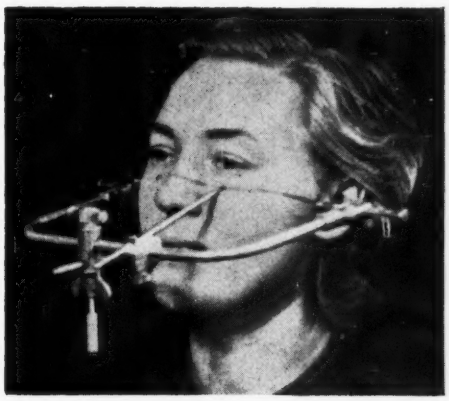

Fig. 9.—Face-bow registration with an orbital pointer. (From Beyron.)

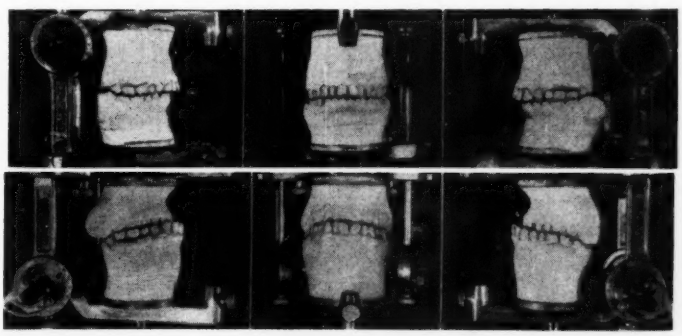

Fig. 10.—The upper illustrations represent casts mounted according to Bonwill's method. In the lower illustrations, the casts were mounted by means of a face-bow and according to the Frankfort plane. It will be observed, especially on comparing the two frontal illustrations, how irregularities in the position of the teeth become apparent when mounting with a face-bow. (From Beyron.)

During recent years there has been a growing tendency to employ a plane that corresponds to what is known as the Frankfort plane. On the face-bow, which is still of the same type as Snow's, a pointer is attached, the end of which touches the lowest point of the infra-orbital margin. When mounting in the articulator, the end of the pointer is placed on a level with the intercondylar shaft (Fig. 9).

What significance has this application of the face-bow? Why does it not suffice to insert the casts in an articulator in accordance with Bonwill's method? When we begin to use a face-bow for mounting casts, we find, in practically every case, that the median line of the upper cast by no means coincides with the median plane of the articulator, which Bonwill probably supposed was the rule. There are also cases, especially if the teeth are still present, where the occlusal plane is

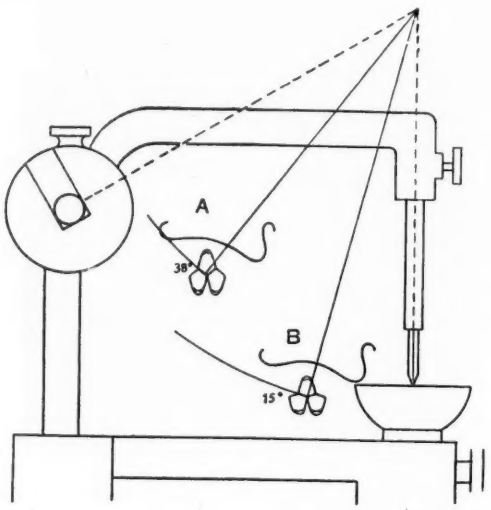

Fig. 11.—The diagram shows how varied the inclinations of the cusp plane can be when the casts are placed in different positions in the articulator. Of course, such great differences in position do not really occur; but changes do actually take place even in connection with smaller deviations from the correct position. (From Swenson).

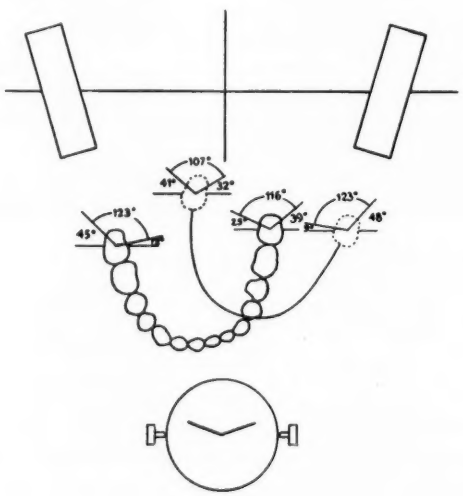

Fig. 12.—The diagram shows the same differences as in Fig. 11, but as seen from above. (From Swenson.)

not situated in a horizontal position, when the articulator is viewed frontally. Nor is this plane horizontal, if viewed laterally. When mounting casts according to Bonwill's method, it is this horizontal position of the occlusal plane that is usually aimed at. These deviations from the horizontal plane are of great importance for the cusp inclines of a prosthetic reconstruction. Furthermore, the average mounting of the casts with Bonwill's method gives us very little information from the diagnostic point of view with regard to disturbances that have

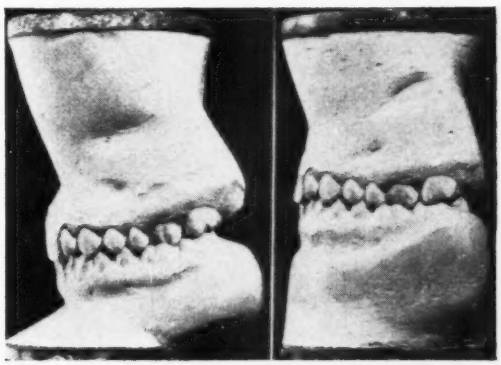

Fig. 13.—*Right* mounting according to the average value of the articulator. *Left,* The Frankfort plane has been used for the orientation of the casts. (From Beyron.)

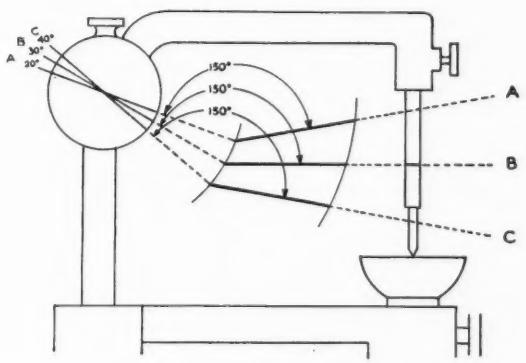

Fig. 14.—A schematic figure showing the variations in the inclination of the condyle path at different levels of the occlusal plane in the articulator. The continuous parts of the lines A, B and C represent different levels of the occlusal plane. Line B is situated on the average-value level, and line C shows approximately the position where, in general, the occlusion plane is situated when the Frankfort plane is used (cf. Fig. 13.) (From Swenson.)

taken place on account of the position of the teeth. This, on the contrary, is found particularly clearly if a face-bow is employed. It is especially true if the casts have been mounted according to the Frankfort plane (Fig. 10).

From what has been stated, it is apparent that the mounting of the casts in the articulator with the aid of a face-bow is of the greatest significance both from a diagnostic and a prosthetic-reconstructive point of view (Figs. 11 and 12).

In this connection, a detail that must be borne in mind is the relation between the level of the occlusal plane of the casts in the articulator and the inclination of the condyle path. When measuring the inclination of the condyle path extraorally according to Gysi's method, the lower edge of the square piece of paper on which the registration takes place is kept parallel to the horizontal part of the face-bow

Fig. 15.—Shows the method of marking the condyle point. (From Beyron.)

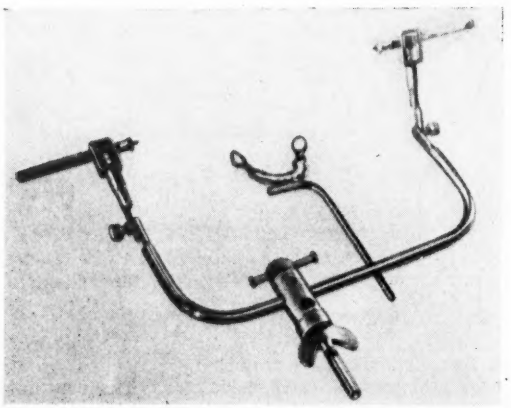

Fig. 16.—A modified face-bow. The ends of the two branches are movable, and the drawing leads are inserted at the ends of the condyle rods. The bite-fork is also modified. A splint, which is carefully fitted to the patient's lower teeth, is soldered to the handle of a fork. (From Beyron.)

(Fig. 5). In this way the inclination of the condyle path is reproduced in relation to a certain plane. In the case of intraoral registration, for example, with a checkbite, we have no such plane to guide us. If we mount the casts in the articulator according to Snow's principle, the value obtained for the inclination of the condyle path will be quite different from that for casts mounted according to the

Frankfort plane. When mounting according to the latter plane, the casts will have a lower position in the articulator (Figs. 13 and 14), and, as a consequence, the inclination of the condylar path will be steeper.

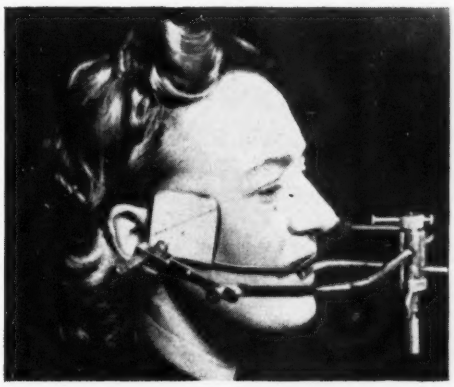

Fig. 17.—The modified face-bow is attached to the patient's lower teeth by means of a splint. A cardboard disc is placed in the condyle region by means of a head-band. The orbital line is traced on this disc and the condyle point, which is approximately determined, is marked. The drawing lead, attached to the condylar rod, rests on the cardboard disc at a little distance from this point. (From Beyron.)

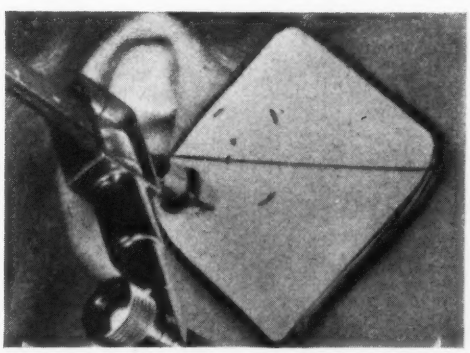

Fig. 18.—The cardboard disc is magnified. The patient is allowed to make repeated small opening movements with his mandible in a retruded position. The condyle rod has been moved to different parts of the disc. The opening movements have been traced as small circular lines. all of which of course have a common center. In the present case, this center is just above the orbital line in the vicinity of the condyle point that has been determined approximately. (From Beyron.)

We have seen how a much more accurate mounting of the casts in the articulator, both in relation to the position of the condyles and to certain points on the head, has been substituted for mounting according to the average value as introduced by Bonwill. This method can, however, be made still more complete by employing certain other measures. When we determine the position of the patient's condyle points in order to find the condyle axis, we utilize the following method. On a line

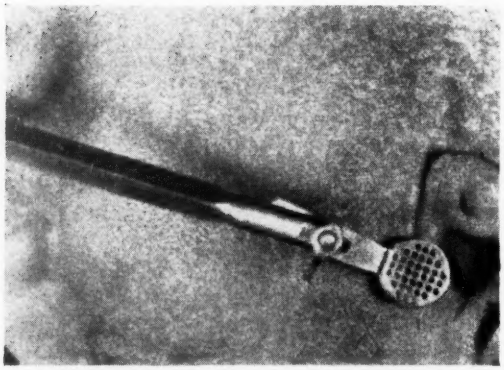

Fig. 19.—Instead of the drawing lead attached to the condylar rod, McCollum used a perforated plate which covered the condyle region. When the opening movements are made, one of the small holes remains fixed as it is situated on the axis of rotation. (From McLean.)

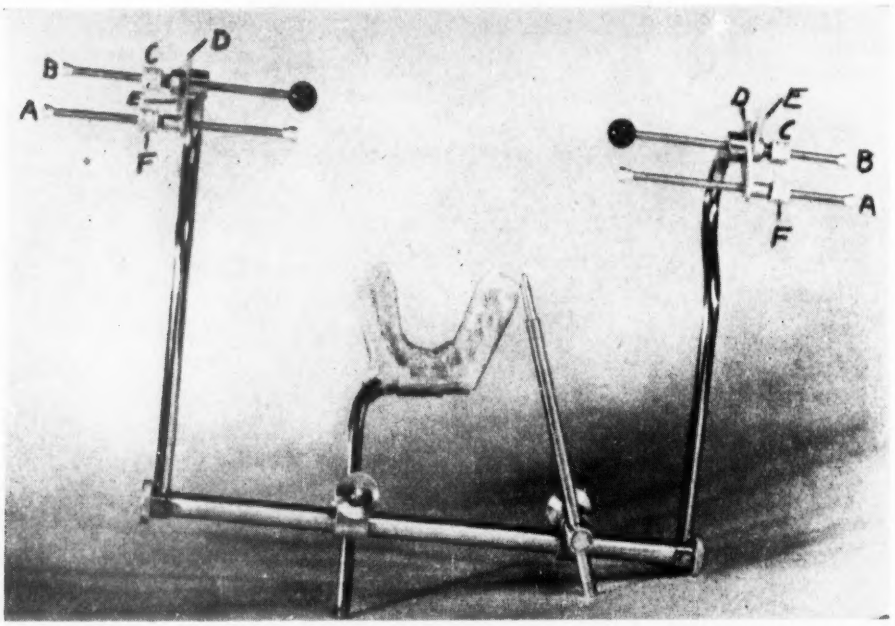

Fig. 20.—The author's face-bow. The rods *B* are equipped with black wooden balls by which the face-bow is attached to the patient's ears. The bite-fork is covered with wax. The bite-fork is placed in the patient's mouth in the usual manner. The locking mechanism of the face-bow is then attached to the handle of the bite-fork, and at the same time the black balls rest on small pieces of cotton wool placed in the patient's ears. The ear rods are fixed by the lock-nuts *C*. The face-bow is now in a fixed position. The lock mechanism for the bite-fork is firmly fixed. The condyle rods are placed on the patient's condyle points and fixed by means of locks *E* and *F*. The orbital pointer is then mounted. Finally, the ear rods are unlocked and withdrawn from the ears. The registration is now completed and the face-bow can be removed.

Fig. 21.—A patient with the face-bow in position.

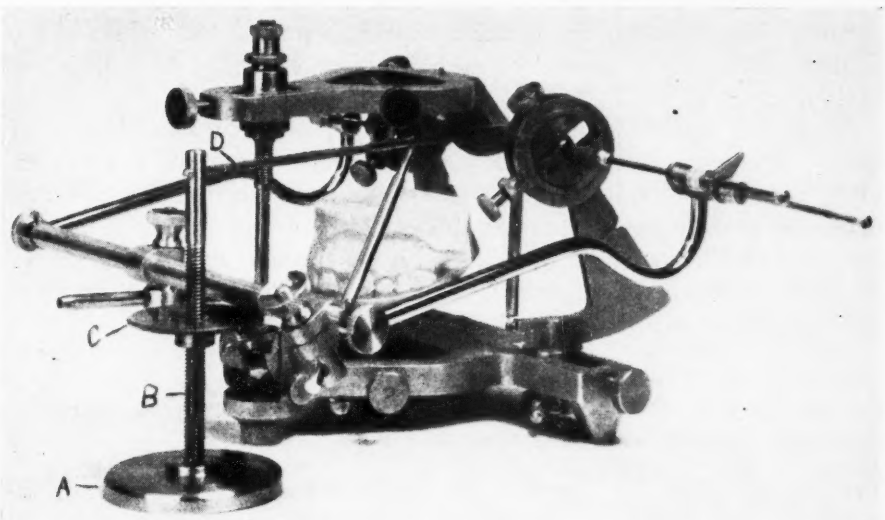

Fig. 22.—The face-bow applied to the author's articulator. The distance between the condyle points is measured by the graduations of the condyle rods. As an example, one of the graduations reads 7.5 cm. and the other 6 cm., together 13.5 cm., i.e., the distance between the patient's condyle points which have been marked out on the skin in front of the tragi. The condyle centers are regarded as being situated 1.5 cm. inside the condyle points. Consequently, the distance between the condyle centers is 10.5 cm. in this case, and the articulator can be adjusted accordingly.

In order to attach the face-bow to the intercondylar shaft of the articulator, the distance between the ends of the condyle rods must be 15 cm., as this is the length of the intercondylar shaft. In the present case, this distance has to be increased by 1.5 cm. in all. If this is done by moving each of the rods 0.75 cm. laterally, the position of the plaster cast will not be altered in relation to the instrument. The face-bow can then be applied to the articulator. There are small holes in the ends of the condyle rods which exactly fit the ends of the intercondylar shaft.

In order to obtain the correct level of the upper cast, a special contrivance has been constructed. A threaded post *B* is supported by the foot *A*. A horizontal circular plate *C* is attached to *B*. This plate can be raised or lowered by a rotary movement. To the upper end of the post *B*, a rod *D* is attached horizontally and at the same level as the intercondylar shaft of the articulator. The face-bow, which rests on the circular plate *C*, can be raised until the orbital pointer touches the rod *D*. The face-bow is then applied to the articulator in the correct three-dimensional position.

extending from the tragus to the lateral angle of the eye a point is marked at about 12 mm. in front of the posterior margin of the most prominent point of the tragus. The presumed condyle axis is supposed to pass through these points which are called the approximately determined condyle points (Fig. 15).

Smaller opening movements of the mandible, in the form of rotation, are assumed to take place around the condyle axis. We consider that the centric relation of the mandible is retained, even if, for example, we place a checkbite between the teeth for a centric occlusion registration. This is not always quite correct, however. The center of the condyle is not always situated *inside* this approximately determined point, and investigations also have shown that the axis of motion does not always pass through the centers of the condyles. Beyron, among others, has demonstrated this experimentally. He determined the position of the axis of motion graphically (Figs. 16, 17, and 18).

Beyron's investigations showed that the position of this axis and those of the condyle points rarely coincide; but that they are nevertheless close to each other. If we wish to be really exact, we should, of course, endeavor to determine the position of this real axis of motion, and then make use of it by our registration with the face-bow. The axis is, however, so near to the approximately determined axis that such a complicated form of registration is scarcely necessary for our practical work. McCollum has constructed a special apparatus that permits of a more rapid determination of the position of the axis of motion than by the graphic method (Fig. 19).

Finally, we should like to mention some practical aids for the fixation of the face-bow. By means of special contrivances, attempts have been made to fix the condylar rods on the condyle points, and in this way to facilitate the application of the face-bow to the patient. An apparatus of this kind, that resembled a spectacle-frame, was supplied with S. S. White's face-bow about twenty-five years ago. Wadsworth employed this apparatus. (See Fig. 8.) We have tried to solve this problem in another way (Figs. 20, 21, and 22).

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PHYSIOLOGIC AND NEUROLOGIC OCCLUSION

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THE TEETH THAT make up the dental organ are important factors in the process of digestion. The primary function of this organ is the comminution of food. The movements of the organ during mastication are cyclic in nature, and are in a general vertical direction. Strange as it may seem, there is little or no occlusal contact between the upper and lower teeth during mastication. However, there are a great many of these vertical movements that do make contact with the upper teeth when food is not present in the mouth. The natural occlusal movements of the dental organ, in the absence of food, are as follows: closing into centric occlusion; closing at the conclusion of the swallowing function; and the many minor cyclic movements that are unconsciously performed during the day.

The closing and the cyclic movements are the physiologic occlusal movements of the dental organ. Therefore, these are the mandibular movements that should be used for establishing occlusion whenever these surfaces are restored or when the natural cusps need to be conformed to such movements. There are no adjustable instruments made for the reproduction of the individual cycles. Adjustable articulators may be used for approximating the closing movements, but the final testing should be made in the mouth.

The occlusal surfaces of natural and artificial teeth are conformed to the cyclic movements by the direct method after centric occlusion has been established. Premature contacts are detected by placing a thin wafer of wax between the upper and lower occlusal surfaces, and asking the patient to perform the chewing movements. A perforation in the wax indicates a premature contact. All occlusal restorations and replacements should be tested for premature contacts by the direct method after they have been placed in the mouth, and regularly thereafter in order to maintain proper occlusion.

One of the outlets for persons with symptoms of nervous hypertension is the neurologic occlusion of grinding the teeth. This grinding action is known to the periodontist as bruxism, and to the prosthodontist as lateral and protrusive movements. In both instances they are recognized as abnormal movements of the mandible by dental physiologists, and therefore should not be used for conforming the occlusal surfaces of every replacement or restoration.

There are cases of highly nervous persons, however, who do require that occlusal surfaces of the teeth be adjusted to these abnormal movements. Many of these cases are so intense that grinding is performed for hours at a time, with a great

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many of them grinding their teeth at night. Meticulous care must be exercised in these cases, and every effort made to have the occlusion so free that the patients will be unable to find the slightest high spot to focus their occlusal neurosis.

There are two methods for reducing the premature contacts of the bruxism patient. These lateral neurologic movements, unlike the vertical physiologic movements are in a general horizontal direction, so that when the direct method is used, the patient is requested to glide from side to side and to move the jaw forward and backward instead of using the up-and-down chewing movements to locate the premature contact points. The indirect method consists of mounting the dentures on an adjustable articulator and transferring static checkbites from the mouth to the instrument, and then reproducing the lateral and protrusive movements on the instrument. However, for superior results the dentures should be finally checked by the direct method, using the natural facilities of the mouth.

Since it has been established that there are two groups of occlusal movements, it should be noted that each group has separate cusp areas to be recontoured—in other words, the same areas are not ground for both of these movements. The general rule for contouring the cusps for the masticating cycles is, to grind the buccal cusp of the lower and the lingual cusp of the upper. The rule for reshaping cusps to the lateral glides is just the reverse—grind the buccal cusp of the upper and the lingual cusp of the lower.

The recent studies made in the occlusion of natural and artificial teeth indicate a definite trend toward the application of dental physiology and the use of the natural facilities of the mouth. The physiologic precept that the occlusal form should follow the function of the dental organ is being recognized as our knowledge of dental physiology is increased.

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OCCLUSION IN PROSTHODONTICS

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A REVIEW of prosthetic literature on occlusion reveals that one author uses a term to mean one thing while another author uses the same term to mean something entirely different. Further, when this same term is used by an author who writes in a field other than prosthetics, such as anatomy or orthodontics, it may be used with a meaning different than that of either of the prosthetic authors. This results in confusion and misunderstanding that discourages the student of prosthesis and impairs his work.

While the problems of occlusion as they relate to prosthodontia are complicated enough in themselves, the confusion in terminology in the current literature makes them even more complicated, and more difficult to understand. The objective should be to simplify rather than to complicate.

A separation of the different components of occlusion and the designation of the various aspects of occlusion should simplify the objective of universal understanding of, not only occlusion itself, but of the discussions of occlusion as well.

COMPONENTS OF OCCLUSION

The components of occlusion as interpreted by prosthodontics are (1) the temporomandibular joint, (2) the musculature, (3) the tissue support for the denture bases, and (4) the teeth. The problem of occlusion in prosthodontics is the proper relation of each of the components of occlusion to each other in varying situations. The impossibility of discussing all of the various concepts of the role of each of the components of occlusion in the limited time is obvious. So only the most pertinent of the various interpretations of these roles will be mentioned. No attempt to refer to specific authors will be made, but the ideas expressed by the many authors on these subjects will be summarized as we see them.

THE TEMPOROMANDIBULAR JOINT

The majority of prosthodontists recognize the temporomandibular joint as the most important guiding factor of occlusion. It is one of the two connections between the upper and lower jaw which are not changed by the loss of the teeth. It is one component of occlusion which is not in the control of the dentist, but which must be accepted by him as it exists in the patient's head.

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This discussion of the temporomandibular joint will be limited to those phases which are essential to prosthodontic interpretation.

The temporomandibular joint is a diarticular ginglymo-arthrodial joint between the mandible and the skull (Fig. 1). The female part of the joint consists of the bony glenoid fossa with its investments, and the male part of the joint is the bony condyle with its investments. Interposed between these parts is the meniscus and two synovial sacs.

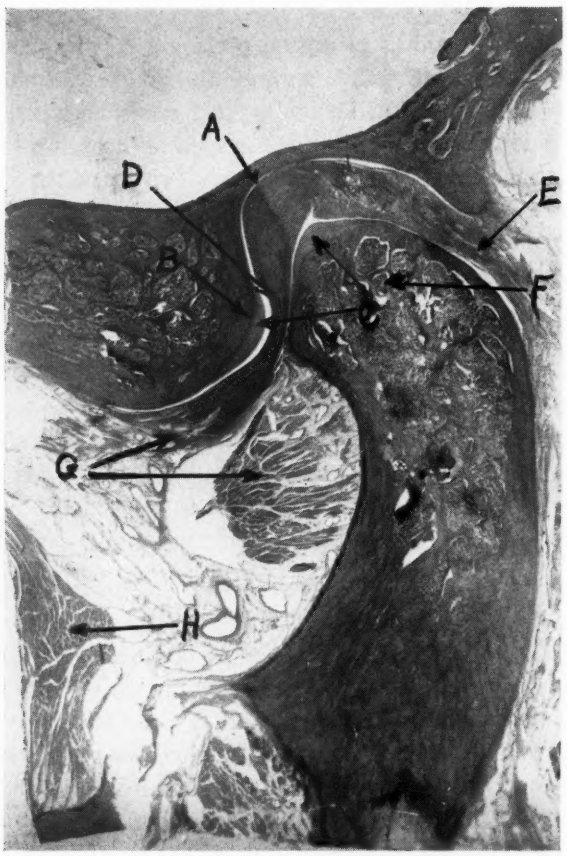


Fig. 1.—A histologic section through the temporomandibular joint in a sagittal plane. *A*, glenoid fossa; *B*, articulating eminence; *C*, fibrocartilaginous covering; *D*, meniscus; *E*, areolar tissue; *F*, condyle (note the irregular shape); *G*, external pterygoid muscle (a horizontal muscle); *H*, internal pterygoid muscle (a vertical muscle).

The glenoid fossa is concave upward. Its deepest part is a thin layer of compact bone without a fibrocartilaginous covering. This would indicate that pressure is not normally applied against it. The anterior part of the glenoid fossa consists of cancellous bone which is covered by a cortical plate *and* a fibrocartilaginous covering. This would indicate that pressures are normally exerted against it in certain jaw positions. The posterior part of the glenoid fossa consists of thin plates of compact bone without a fibrocartilaginous covering. The petrotympanic

fissure is located between these thin plates of bone. This part of the glenoid fossa contains part of the capsular ligament and areolar tissue. Obviously, pressures should not be applied distally against this part of the fossa.

The articular meniscus is a fibrocartilaginous disc which is placed between the condyle and the glenoid fossa. This is a synovial cavity or sac above it and another below it. These structures are found where pressures are applied.

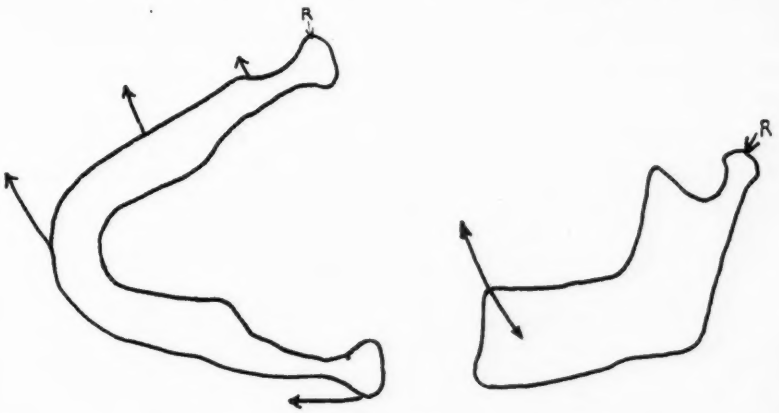


Fig. 2.—Simple rotations. *Left,* in the horizontal plane. *Right,* in the vertical plane.

Fig. 3.—Factors influencing a simple protrusive movement when no teeth are involved.

The condyle is of cancellous bony structure with a compact outer layer which is covered above with a layer of fibrocartilage. The structure of the condyle permits it to withstand upward stresses. In normal conditions, pressures are applied through the condyle to the glenoid fossa only when the mandible is protruded from its rest position in centric relation.

MOVEMENTS IN THE TEMPOROMANDIBULAR JOINT

The movements in the temporomandibular joint are many and varied. They may occur below the meniscus, or above the meniscus, or in both parts of the joint simultaneously. Most prosthodontists believe that the movements in the lower part of the joint are limited to rotations, either in the vertical or horizontal plane, or in

combinations of these (Fig. 2). The other movements are believed to occur in the upper part of the joint.

The movement which occurs in the joint when the mandible is carried forward in protrusion is in a downward and forward direction. The condyle and meniscus are guided downward by the articulating eminence of the glenoid fossa (Fig. 3). The angle of this glide may vary from patient to patient, and from side to side of the same patient. The position of the articular disc in relation to the condyle during this movement may alter the angle of the movement from that indicated by the bony structure. This is due to the variation in the thickness of the meniscus in its different parts.

The movement that occurs in the temporomandibular joint on the working side (the side toward which the mandible is moved) is one of rotation, chiefly in a horizontal plane (Fig. 4), but modified by the vertical opening produced by the

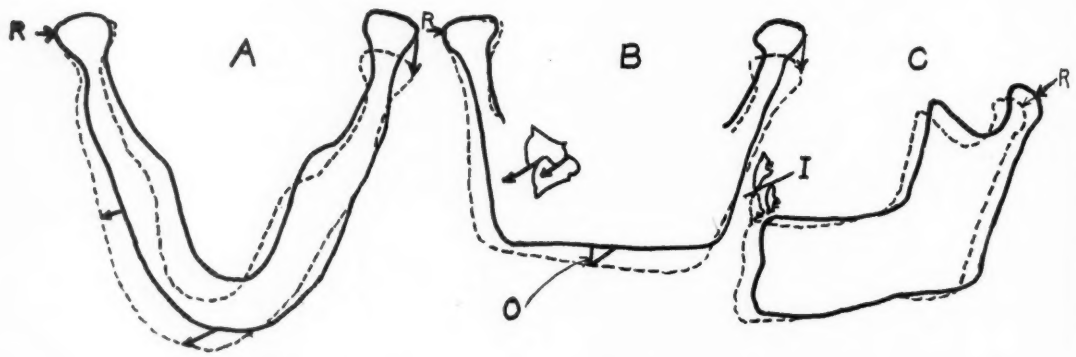


Fig. 4.—Rotations into right lateral occlusion. *A*, Rotation around the working side condyle involves a downward, forward, and inward movement of the balancing side condyle. *B*, Rotation around the working side condyle involves a downward and forward movement of the balancing side condyle *and* an opening rotation "O" which is produced by the height of the cusps. *C*, The rotations of the mandible cause a protrusion of the balancing side which has as its guidances the inclination of the condyle path and the incisal guidance "I" (or cusp height).

height of the cusps, and by the downward and forward movement of the balancing side condyle. This movement is believed to occur in the lower part of the joint.

Simultaneously, in some mouths and with wide variations in direction and magnitude the mandible slides laterally (the Bennett movement) (Fig. 5). This slide is thought to be due to the angle at which the external pterygoid muscle on the balancing side is placed in relation to the condyle. This movement occurs in the upper part of the joint. It may be in the horizontal plane or it may be slightly upward, downward, or backward, depending upon the shape of the glenoid fossa on the working side and the relation of the condyle to the disc during the movement.

The movement that occurs in the temporomandibular joint on the balancing side (the side opposite the working side) is partly rotary (opening) and partly gliding forward downward and medially (Fig. 6). This is the most obvious deviation from a simple hinge and forward movement of the condyle. It is readily measurable, and is given considerable attention in most denture techniques in use

today. It occurs in both parts of the joint, with the rotation occurring in the lower part and the gliding occurring in the upper part of the joint. The direction of the glide is determined by the shape of the glenoid fossa and its fibrocartilaginous covering, the relation of the articular disc to the condyle, the magnitude of the lateral movement, and the amount of lateral slide (Bennett movement) of the mandible. It is of extreme importance to the prosthodontist who is to develop a "balancing contact" of teeth on the balancing side when the teeth on the working side are in contact in lateral protrusive positions.

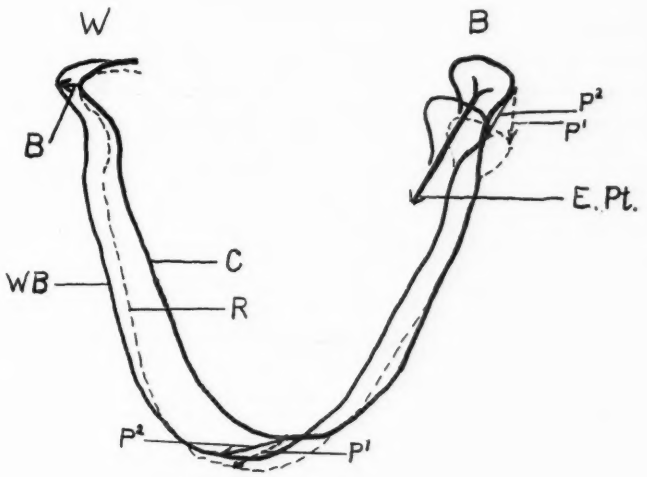


Fig. 5.—The effect of the Bennett movement. *C*, centric position; *R*, the position of the mandible after a simple rotation; *WB*, the position of the mandible when a Bennett movement has occurred. P^1 is the direction of movement when a simple rotation occurs. P^2 is the direction of movement when a Bennett movement is added to the rotation. While the working side condyle *W* rotates, it also glides laterally. The balancing side condyle *B* is pulled forward and medially by the external pterygoid muscle *E.Pt.* as it is guided downward by the articulating eminence and the meniscus.

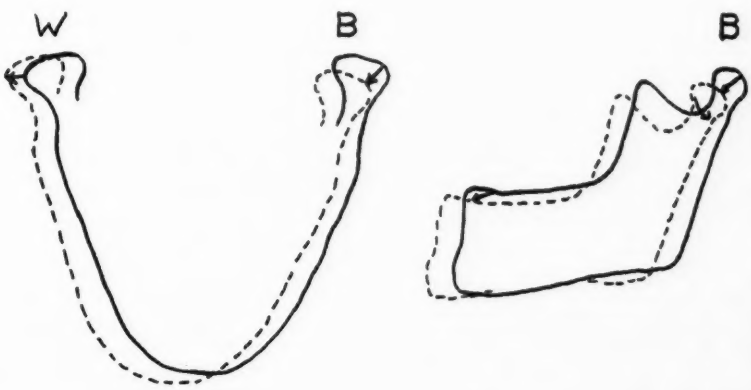
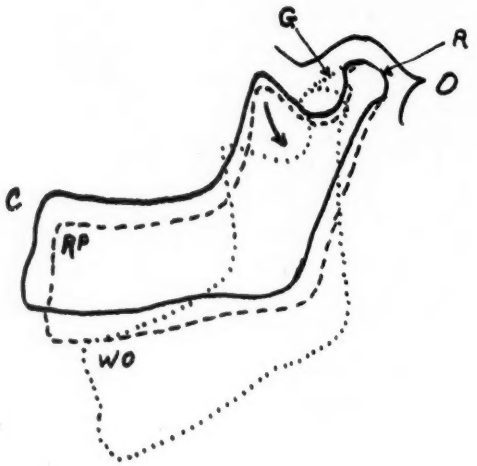


Fig. 6.—*Left*, the direction of movement in the horizontal plane in right lateral excursions. *Right*, the balancing side condyle moves forward while it is guided downward. The condyle rotates simultaneously in an opening direction because of the height of the cusps of the teeth.

The movement in the temporomandibular joint which has provoked more differences of interpretation than any other is that which occurs during the opening of the mouth (Fig. 7). The simplest and apparently the most logical of these interpretations is that, for practical purposes of prosthodontics, a simple rotary movement occurs in the lower part of the joint from the vertical dimension of occlusion during the opening of the mouth until the vertical dimension of rest position is reached. Further opening involves a forward and downward movement of the condyle and the meniscus in the upper part of the joint along with further rotation

Fig. 7.



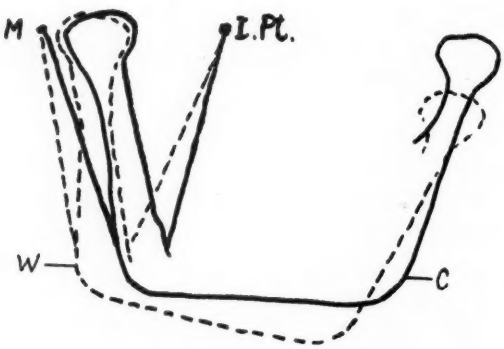


Fig. 8.

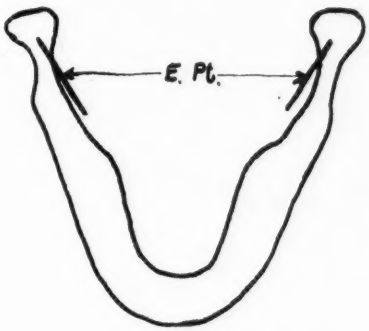
Fig. 7.—Opening movements of the mandible. *C*, the position of centric occlusion. *RP*, the position of physiologic rest. *WO*, the wide open position. *R*, the rotational center for movements from the centric occlusal position. *G*, the guiding influence of the articulating eminence and the meniscus.

Fig. 8.—The effect of jaw position on the direction of muscle force. *C*, centric position. *W*, working position. *M*, masseter muscle, *I.Pt.*, internal pterygoid muscle. Note how their relative angles change with the change in jaw position.

in the lower part of the joint. Closures beyond the vertical dimension of occlusion are apparently simple rotations in the lower part of the joint, but modified by the irregular articulating surface of the condyle and by the soft tissues in the fossa. See Fig. 1.

It is obvious that this discussion of the movements of the condyle in the glenoid fossa has not covered all of the various intermediate movements which are various combinations of these essential movements. This would be impossible in

Fig. 9.



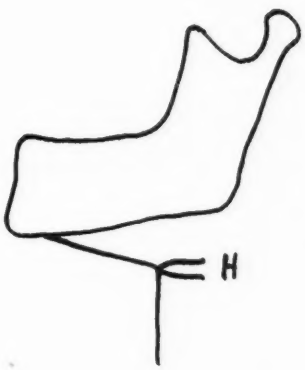


Fig. 10.

Fig. 9.—The direction of force of the external pterygoid muscles.
Fig. 10.—The opening muscles of the jaw (the inframandibular muscles). *H*, the hyoid bone.

the time allotted, so we may be criticized for oversimplification. However, if the essential or basic movements are understood, the others will be easily understood.

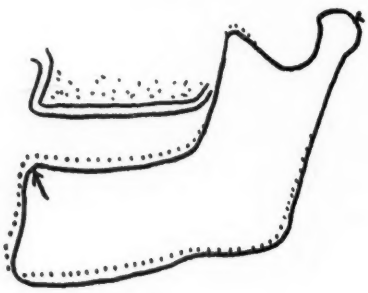
MUSCULATURE OF OCCLUSION

The importance of the musculature of the mandible as it relates to occlusion is becoming increasingly apparent to prosthodontists. The muscles' control of

the position of the mandible make them an important component of occlusion in the static jaw relations as well as in its kinematic relations.

The muscles that control and move the mandible may be considered in three groups. These are the closing muscles, the guiding muscles, and the opening muscles of the mandible. For purposes of this discussion, these groups of muscles and their functions will be described as simply as possible, with a minimum of detail.

Fig. 11.



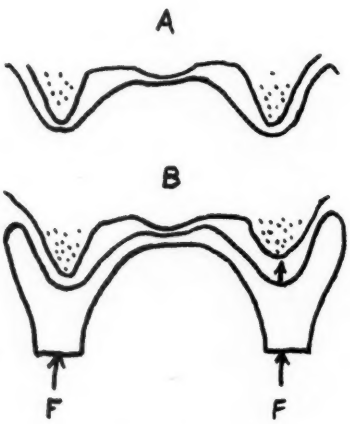


Fig. 12.

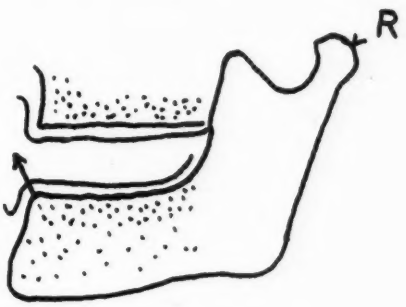
Fig. 11.—The change in maxillomandibular relations as the result of tissue resiliency. Closing pressures cause the two bones to approach each other more closely than at the first contact of the teeth.

Fig. 12.—Force applied on a denture base will cause more movement of the base on the side with the thickest soft tissue.

Several factors regarding these muscles must be recognized immediately. (1) Like all muscles, they act by contraction, so they pull instead of push. (2) The direction of their fibers at the time of contraction determines the direction of their action. (3) The number of fibers contracting at a given time determines the amount of force produced. (4) A tonic contraction of the different muscle fibers occurs even when the muscle is at rest. (5) Whenever a muscle fiber contracts, it contracts to the maximum of which it is capable.

The closing muscles of the mandible are the masseter, the temporal, and the internal pterygoid. They are so listed because the direction of most of their fibers is essentially vertical, and their origin is superior to their insertion on the mandible. They are the source of power for closing the teeth into occlusion. The direction of the specific contracting fibers within each of these muscles will determine the direction of the force applied by those fibers. This direction can be altered by the relative position of the mandible at the time the contraction occurs (Fig. 8). For

Fig. 13.



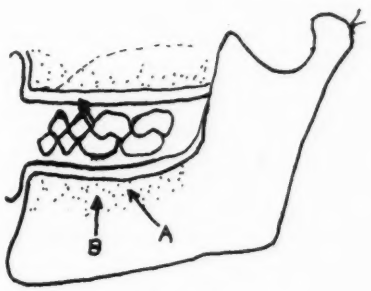


Fig. 14.

Fig. 13.—The horizontal relation of the bones is changed as occluding pressures are applied and the soft tissues are displaced.

Fig. 14.—The effect of tissue displacement under occluding forces on occlusion. A rotation, *A*, causes the body of the mandible to assume a more forward position after tooth contact as a result of its relation to the rotating axis. This develops a forward thrust on the occluding teeth. Closures in direction *B* from a protruded position do not cause this forward thrust.

example, when the mandible is in a right lateral position and the closing muscles contract, the right internal pterygoid muscle will exert a force that is directed more medially than if the mandible were centrally placed (in centric position).

The external pterygoid muscles are the guiding muscles of the mandible (Fig. 9). They furnish the power for steering the mandible into a position which is most favorable for mastication of the food being chewed at the moment. Their second function is to complete the masticatory cycle, in certain situations, after the closing muscles have accomplished as much as they can. The action of the external

pterygoid muscles is to pull the mandible forward if they both contract simultaneously, or to pull the mandible laterally if they contract individually. They also pull the meniscus forward with the condyle. Their origin is anterior and medial to the condyle so the force they apply is in that direction.

The opening muscles of the mandible are those whose origins are below the mandible (Fig. 10). They are divided into two groups, the suprahyoid and the infrahyoid muscles. The infrahyoid group serves to anchor the suprahyoid group during their contraction. This anchorage can be at varying levels according to the amount of contraction of the infrahyoid group. The direction of the action of the suprahyoid group of muscles is downward and backward.

The power potential of the opening muscles is much less than that of the closing muscles because of the smaller number of muscle fibers involved. However, there is a perfect balance of power between them when the mandible is at rest at the vertical dimension of rest position. This requires that the mandible be so positioned that both the opening and closing muscles be established at the optimum length for the tonic contraction of rest. This "rest position" of the mandible requires that the guiding muscles, also, be in no more than tonic contraction. When these conditions are met, the mandible is in *a* centric relation to the maxilla at the vertical dimension of rest position.

It has been shown that the maximum effectiveness of the closing muscles of mastication is at the jaw separation (vertical dimension) of rest position, and that the power delivered by the closing muscles decreases upon further closure or further opening of the jaw from rest position. This may be open to some question as the tests were made on the anatomic foundation of edentulous ridges. None of the registrations of the closing power of these muscles equalled the registration of muscle power with natural teeth.

The vertical dimension of rest position is an important factor in prosthodontics, but it is not a "working" registration. It is a *guide* to the vertical dimension of occlusion which is the "working" registration necessary to prosthodontics. The casts of the jaws must be related to each other in the vertical dimension of occlusion in order that teeth can be arranged.

TISSUE SUPPORT

The prosthodontist must consider tissue support of the denture bases as an essential component of occlusion. This support consists of bone and soft tissue. The histologic structure of these tissues is not pertinent to the concept of occlusion being discussed, but the general characteristics of these tissues are of extreme importance.

The base foundation for the occlusion of artificial teeth is the bone of the maxilla and the mandible. Bone is a most plastic tissue which will not withstand sustained pressures. Therefore, provision for its rest must be made in the occlusion. This is done by establishing a free-way space between the teeth when the musculature is at rest at the vertical dimension of rest position.

Bone is apparently more susceptible to lateral or rotating forces (such as those developed by occlusal disharmony) than to forces applied in a direction perpendicular to it (such as those of mastication). The shape of the bony support is

not particularly favorable for the proper development of the direction of the forces to be applied against it in many mouths. This is particularly true of the mandible. Compromise is often necessary in the establishment of the vertical dimension of occlusion, in order to develop a more favorable direction of these forces against the bony support. It is entirely possible to have the vertical dimension of rest position perfectly established, and the vertical dimension of occlusion established with an adequate free-way space, and yet have the dentures be unsatisfactory because the shape of the bony support causes them to slide on the ridges.

Fig. 15.

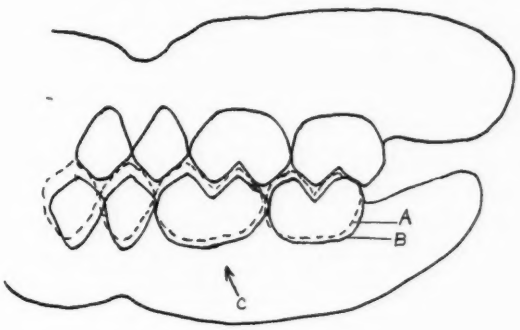


Fig. 16.

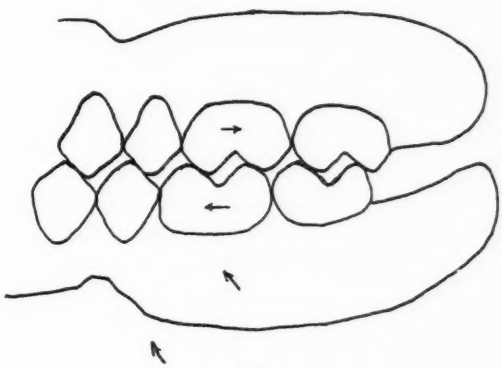


Fig. 15.—*A*, Tooth contacts under heavy pressure. *B*, Tooth relations at first contact when the jaw relations are recorded under heavy pressure. *C*, Direction of movement of the denture while heavy occluding pressures are applied.

Fig. 16.—The effects of occlusal disharmony when the patient exerts occluding forces without food in the mouth.

The soft tissues which cover the bone are important to occlusion because of their resiliency. Without a doubt, prosthodontists would have much less difficulty in recording all jaw relations if they had solid attachments to the bone of maxilla and mandible. The resiliency of these soft tissues permit even the best denture bases to move vertically as well as horizontally at the time registrations are made, and after the dentures are completed. The amount of this movement is proportional to the thickness of the soft tissues. (See Fig. 12.) The vertical movement of the

bases is not necessarily uniform throughout the base area. The soft tissues vary in their thickness in various parts of the foundation, and permit more movement of the bases in the areas covered by a thick layer of soft tissues than in the areas where the soft tissues are thinner. If jaw relations are recorded under the pressure of closure, the uneven vertical movement of the denture bases will cause casts to be mounted on the articulator in a different relation than if the records had been made without pressure (Fig. 11). The vertical movement of the denture bases in relation to their bony foundations during jaw relation recording procedures will cause premature contacts of the teeth on the side (right or left, front or back) which is displaced vertically to the greatest extent (Fig. 12).

The vertical movement of denture bases when closing pressures are applied changes not only the relation of the bases to the bone, but it also changes the vertical and horizontal relation of the mandible to the maxilla (Fig. 13). The decrease of the vertical separation of the two bones causes the body of the mandible to move forward in relation to the maxilla even with the condyles in their most retruded position in the glenoid fossae. This is because the body of the mandible is at a lower level than the temporormandibular joints around which the movement occurs (Fig. 14). This forward movement of the body of the mandible may cause a disharmony in the occlusion of the teeth when they are subjected to chewing pressures.

Some prosthodontists favor jaw relation records that are made under the pressure of jaw closure. They feel that it is more important to have the stress of occlusion borne uniformly by *all* the foundation tissues even though the teeth do not contact simultaneously at their very first contact (Fig. 15).

Other prosthodontists favor jaw relation records that are made under the minimum of pressure exerted by the patient. They feel that the most damage to the denture foundation is done by the tooth contacts that do not involve maximum closing forces (Fig. 16). The uneven contacts cause the patient to "chew" his teeth and to glide the lower teeth over the upper teeth by an intermittent application of closing forces. This frequent and often continuous application of force, which tends to cause the denture bases to shift in relation to the tissue support, causes soreness and destruction of the foundation base.

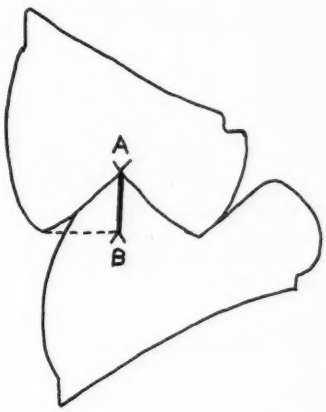
TEETH

The fourth component of occlusion is the teeth themselves. The prosthodontist, unlike workers in other branches of dentistry, has a choice of various occlusal forms of teeth. They range from high cusp (45 degree) to the flat (0 degree) cuspal inclinations. Cusp teeth (45 degree and 30 degree) are considered as anatomic teeth, although the forms do not duplicate nature's cusp forms. Modified occlusal forms are those with a 20 degree cuspal inclination or less.

There are three schools of thought on the choice of occlusal forms of teeth for prosthetic restorations. Those who favor the use of anatomic teeth insist that the tooth that nature designed is best for the function of mastication. Cusp teeth have cutting blades so arranged that a part of the nearly vertical closing force can shear food. They have contours that can crush and triturate food when the proper forces

are applied. They have adequate sluiceways or escapes for food which will avoid the need for excessive pressures. The chewing efficiency for some foods is greater than that of the modified tooth forms. They have cuspal inclinations which facilitate the development of bilateral balance (contact) in the various eccentric occlusions (Fig. 17). Cusps provide thickness of the occlusal pattern in eccentric occlusions which assists in the development of balanced occlusion. The chewing cycle as it is viewed from the front is more nearly vertical than it is with flat cusp teeth. (See Fig. 22.)

Fig. 17.



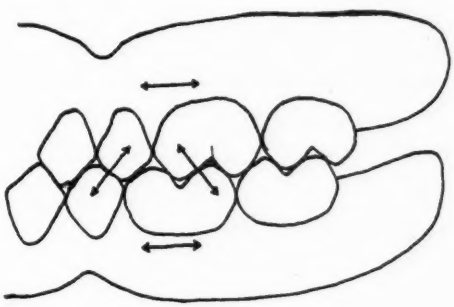


Fig. 18.

Fig. 17.—Distance *A—B* represents the thickness of the occlusal pattern in eccentric occlusions.

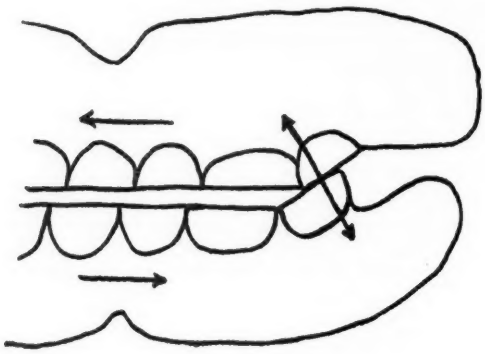
Fig. 18.—Any possible tendency toward rotation produced by balancing tooth inclines is neutralized by the opposing inclines of cusps on the working side.

Cusp teeth provide a resistance to the rotation of dentures in relation to each other and in relation to the bases which flat cusp teeth do not (Fig. 18). The interdigitating cusps on the working side provide neutralizing incline plane contacts which tend to prevent rotation of the denture bases. Pressure on a balancing ramp or inclines tends to make the lower denture rotate to the distal on the balancing

side and tends to rotate the upper denture to the mesial on the balancing side (Fig. 19).

It is claimed by those who prefer the modified occlusal forms that the intercuspation of the cusp teeth causes damage to the basal seat of the dentures as vertical dimension of occlusion is lost through shrinkage of the ridges. The loss of the foundation of the dentures permits the jaws to close beyond the level at which occlusal contact was made when the dentures were first inserted. This causes the body of the mandible (and the lower teeth) to move forward. The forward movement of the

Fig. 19.



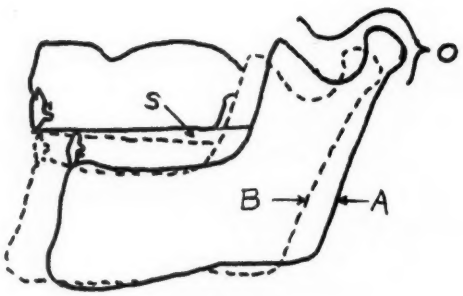


Fig. 20.

Fig. 19.—The balancing ramp or inclines tend to cause the upper denture to rotate forward and the lower denture to rotate backward on their basal seats.

Fig. 20.—*A*, The mandible in centric position. *B*, The mandible in a protruded position. *S*, the space produced by the downward movement of the condyle in eccentric positions. This produces heavy contacts anteriorly whenever the teeth contact in eccentric positions.

body of the mandible causes the mesial inclines of the cusps of the lower teeth to make their first contacts against the distal inclines of the cusps of the upper teeth. The teeth can thus no longer contact in centric occlusion even though the mandible is in centric relation. The upper denture is forced forward and the lower denture is forced backward by this malrelation.

Most modified tooth forms provide an anteroposterior freedom even though they may have some lateral cuspal inclination. Most modified tooth forms permit

more latitude in their arrangement anteroposteriorly than cusp teeth. Their reduced efficiency in mastication is compensated for in part by their reduced buccolingual diameters of their working occlusal surfaces. Some have adequate escapeways and others do not. Those that do not, require more force for mastication and are less efficient.

There are three deficiencies in teeth with modified occlusal forms. Unnecessarily great vertical occlusal forces are applied to the anterior part of the two basal seats of dentures when the jaw is moved to any eccentric position *without food in the mouth* (Fig. 20). This is due to the fact that the temporomandibular joint forces the posterior part of the mandible to a lower level as the protrusion is made.

Fig. 21.

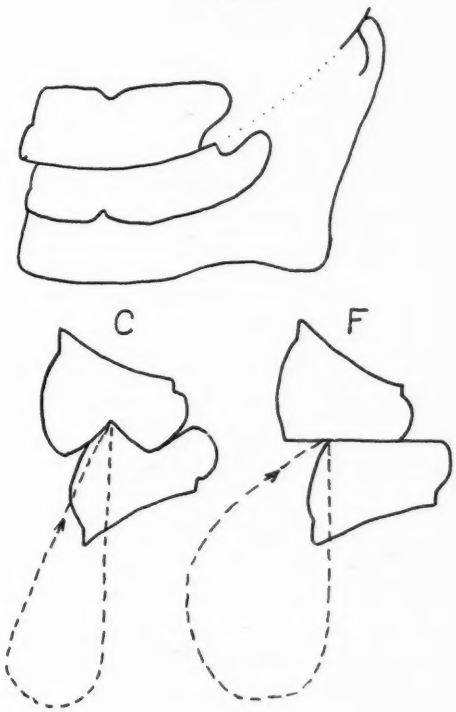


Fig. 22.

Fig. 21.—Flat teeth arranged on a compensating curve.
Fig. 22.—Comparative chewing cycles as viewed from the front. *C*, with cusp teeth. *F*, with flat teeth.

This can be compensated for by developing a balancing contact on a balancing ramp at the distal end of the occlusal surface (see Fig. 19), or by arranging the teeth on a compensating curve (anteroposteriorly and laterally) in the occlusal plane (Fig. 21). The amount of the curve or the height of the ramp required for balancing the anterior contact will vary with the path of the condyle and the relation of the upper and lower anterior teeth to each other.

The second deficiency of the modified tooth forms is the difficulty in developing a contact on the balancing side when the teeth on the working side approach each other with food interposed. The cusp height of cusp teeth allows this contact to be

made while the buccal cusps of the teeth on the working side are separated further from their ultimate seat in centric occlusion than would be possible with flat cusp teeth. (See Fig. 17.)

The third deficiency of modified tooth forms is the change in the chewing cycle. Patients with flat cusp teeth *tend* to have a flatter chewing cycle than with cusp teeth (Fig. 22). The lower teeth approach the upper in a more nearly horizontal angle than with cusp teeth in order to develop a shearing action. This increases the amount of lateral force applied to the denture bases and to their supporting tissues.

The third school of thought regarding the occlusal forms of teeth also involves the modification of tooth forms. Stated simply, the lingual cusps of the upper teeth and the buccal cusps of the lower teeth are removed (Fig. 23). The teeth are then arranged on an anti-Monson curve. The curvature of the occlusal plane is convex upward instead of downward as it is in the curve of Spee, and the compensating curve which is used with anatomic and flat teeth. No effort is made to obtain bilateral balancing contacts in most instances. The greater stability of the upper denture base is used to favor the stability of the lower denture base. The occlusal scheme does offer shearing blades that are not in a flat plane for the mastication of food. The chewing cycle is similar to that of cusp teeth.

THE OCCLUSAL PLANE

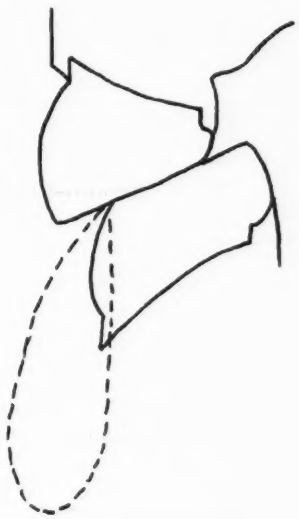
The occlusal plane is the plane on which the upper and lower teeth occlude. Strictly speaking, it is not a plane because the occlusal surfaces of the teeth seldom lie on the same plane, and because it may have thickness when cusp teeth are used and contacts are made in eccentric jaw positions, with subsequent further closure into centric occlusion.

The arrangement of posterior teeth will vary with the occlusal form of the teeth being used, with the steepness of the condylar paths, and with the incisal guidance (Fig. 24). The condylar guidances (the posterior guidances) are recorded from the patient and adjusted on the articulator. The incisal guidance (the anterior guidance) is established by the relation of the upper and lower anterior teeth to each other. This relation is usually established by esthetics. The relative amount of vertical overlap (overbite) to the amount of horizontal overlap (overjet) determines the path followed by the lower incisor to contact the incisal edge of the upper incisor tooth in protrusion. These anterior and posterior guidances are of importance when the anterior tooth contacts are to be balanced by posterior tooth contacts. They determine the need for inclining the occlusal pattern up or down in the back and for the use of a compensating curve in the occlusal plane (Fig. 25). A steep condylar path will require that the occlusal pattern (or part of it) be tipped up in the back, or it will require a compensating curve that is convex downward in order to develop the balancing contacts on the posterior teeth. If the incisal guidance is also steep, the tipping of the occlusal pattern must be increased and the compensating curve must have a smaller radius. If cuspless teeth are used the inclination of the occlusal pattern must be greater and the radius of the compensating curve must be smaller, because the absence of cusps reduces the vertical thickness

of the occlusal plane or range of vertical movements in which contacts are possible. If cuspless teeth are used, any vertical overlap of anterior teeth at all will be disastrous.

The orientation of the occlusal pattern higher posteriorly than anteriorly is generally conceded to be a poor practice. It produces a forward thrust on the upper denture, and a backward thrust on the lower denture (Fig. 26). This causes a

Fig. 23.



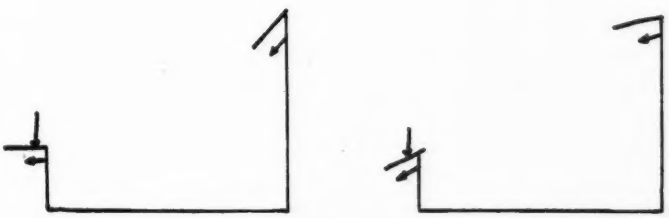


Fig. 24.

Fig. 23.—The chewing cycle of teeth set on an anti-Monson curve is similar to that of cusp teeth.

Fig. 24.—The end guidances in protrusive glides. *Left*, a shallow incisal guidance is indicated for a steep condylar guidance. *Right*, a steep incisal guidance is indicated for a shallow condylar guidance. The objective is to keep the occlusal pattern as nearly flat as possible.

looseness of the bases, soreness, and destruction of the bony foundation. The occlusal pattern should be oriented as nearly parallel to the two alveolar ridges as is possible. The level of the anterior end of the occlusal plane is determined by the position of the anterior teeth, as they are placed for esthetics. The posterior end of the occlusal plane should be near the level of the distal third of the retromolar pad (Fig. 27). This copies the relations found in nature, and places the occlusal plane

at a level which is harmonious with the soft tissues that must work around it. Variations from this position must be made if the occlusal plane is too far from being parallel with the supporting ridges.

Some prosthodontists use certain cranial landmarks as a guide to the location of the occlusal plane. Some make the occlusal plane parallel to the Frankfort or eye-ear plane. Others make it parallel to a plane through the nasion and the auditory meatus. Most prosthodontists, however, modify the orientation of the occlusal plane from these planes to improve the relation between the occlusal plane and the

Fig. 25.

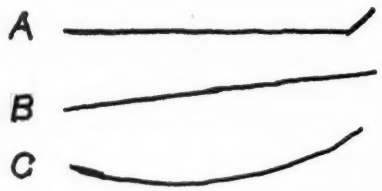


Fig. 26.

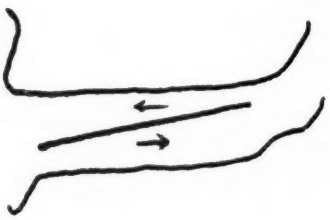


Fig. 27.

Fig. 25.—Occlusal patterns. *A*, Flat with a balancing ramp or incline. *B*, Flat but inclined upward posteriorly. *C*, Curved to correlate with the condylar guidances.

Fig. 26.—The orientation of the occlusal pattern higher posteriorly than anteriorly produces a mesial thrust on the upper denture and a distal thrust on the lower denture.

Fig. 27.—The orientation of the occlusal pattern.

"mean foundation plane." The mean foundation plane is the mean of the inclinations of the denture supporting tissues. This orientation places the occlusal plane in a position most favorable for the application of occlusal forces at right angles to the support for the dentures.

TERMINOLOGY

Prosthodontists think and write of occlusion from two viewpoints. In order that we can understand the various concepts of occlusion as expressed in these viewpoints, it will be necessary to agree upon the meaning of the terms used in their discussion.

Occlusion is the contact of the lower with the upper teeth. It may occur in many different jaw positions. It may be correct or incorrect. It has many subdivisions according to the position the lower jaw is in at the time the contact is made, and according to the type of contact being made.

Centric relation is the most posterior relation of the lower to the upper jaw from which lateral movements can be made at a given vertical dimension. It is implied that all the muscles which protrude or retrude the jaw or move it laterally are at rest. It is the median position of the jaw. The condyles are in their normal rest position in the posterior part of the glenoid fossa, without disturbing forces of malocclusion or muscular action. Centric relation is a jaw relationship and not a tooth relationship. It is the terminal posterior position toward which the closing muscles of mastication pull the mandible. Centric relation is not a forced relation. If it were a position of forced retrusion, no lateral movement could be made from it without a slight forward movement being made first.

Centric relation is thought of primarily as a horizontal relation, but it has a vertical component as well. The vertical component of centric relation is divided into two phases: (1) Centric relation (horizontal) can be recorded at any degree of vertical jaw separation which permits the condyles to stay in the posterior part of the glenoid fossae. Centric relation may differ with varying degrees of vertical jaw separation. This is due to the shape of the articulating surface of the condyle and the relative position of the condyle and the occlusal plane. The centric relation at the vertical dimension at which the teeth occlude is the one with which the prosthodontist must be concerned.

The relative position of the two jaws to each other in a horizontal plane can be indicated by the relation of a stylus, attached to the upper occlusion rim, to a Gothic arch tracing made by the stylus on a tracing table attached to the lower occlusion rim. When the stylus is in the apex of the tracing, the mandible is in centric relation with the maxilla in the horizontal plane. The tracing does not indicate the vertical component of centric relation. A mandible may be in the correct horizontal relation to the maxilla and yet the centric relation record may be incorrect in the vertical plane because of uneven displacement of soft tissues under the denture.

(2) Centric relation is a mandible to maxilla relation (a bone to bone relation) but the prosthodontists must also consider the relation of the denture base to these bones as a part of the vertical component of centric relation. The displaceability of the soft tissues, which support the denture bases, permits the mandible to approach the maxilla more closely under pressure than without pressure. This also causes the *body* of the mandible to move forward into a more anterior relation to the maxilla *without* a corresponding forward movement of the condyles.

Eccentric relations of the jaws are those in any other position than centric relation. They may be protrusive or right or left lateral or intermediate relations. They are thought of as being jaw relations that exist when the teeth are in contact but may exist without teeth when the jaw is closed to the level at which tooth contacts might occur if they were present.

Centric occlusion is the contact of the lower teeth with the upper teeth which involves the maximum intercuspation of the teeth. In centric occlusion, (1) the long

axis of each upper tooth is distal to the long axis of the corresponding tooth, (2) the upper teeth overlap the lower teeth, and (3) each tooth is opposed by two except the lower central incisor and the upper last molar. Centric occlusion is a relation of teeth to each other. Teeth may be related in centric occlusion in or out of the mouth. It is agreed by most prosthodontists that centric occlusion must occur when the jaws are in centric relation at the vertical dimension of occlusion.

Eccentric occlusion is the contact of the lower teeth with the upper teeth in any possible relation other than that of centric occlusion. The relation might be that of forward protrusion, lateral protrusion, or intermediate protrusions. Eccentric occlusions may be made in or out of the mouth, and may or may not be made within the functional range of jaw positions or tooth contacts.

Functional occlusion is that which occurs in the mouth within the functional range of the tooth surfaces. This includes both centric occlusion and eccentric occlusion which do not require more protrusion than the elimination of the horizontal overlap of the teeth.

Balanced occlusion is that in which the upper and lower teeth make simultaneous contacts on the right and left and in the anterior and posterior occlusal areas. This occlusion is developed to prevent a tipping or rotating of the denture bases in relation to the supporting structures. It is thought of primarily in the mouth, but it is arranged and may be observed on articulators. It may or may not exist in centric occlusion as well as eccentric occlusion. It may exist on an articulator but not in the mouth, if the relations of the casts on the articulator and the adjustment of the articulator do not reproduce the corresponding relations and paths of movement of the jaws.

Working contacts of teeth are made on the side of the occlusion toward which the jaw is moved. They occur on the *working occlusal surfaces* of the teeth.

Balancing contacts of teeth are made on the balancing side at the opposite extreme of the occlusal scheme from a designated site. For example, when the mandible is protruded to bring the lower incisors even with the upper incisors (in working contact), the contacting parts of the molar teeth are the *balancing occlusal surfaces.*

VERTICAL DIMENSION

The vertical dimension has caused much apparent disagreement in the literature because the terminology used has different implications or meanings to the various writers. Vertical dimension has to do with the length of the face as it is maintained by either the occlusion of the teeth or by the balance of the balanced tonic contraction of the opening and closing muscles of mastication. The term has been incorrectly used interchangeably. The term vertical dimension should have added to it qualifying phrases which will designate the one vertical dimension that is under discussion.

Vertical dimension of rest position is the vertical separation of the two jaws which exists when the opening and closing muscles are at rest in tonic contraction. It is a postural relation of the two jaws. Vertical dimension of rest position is of value to the prosthodontist only as a means for locating the vertical dimension of

occlusion. It is generally conceded that teeth should not be in contact when the jaws are in the vertical dimension of rest position. This space between the teeth is called the "free-way space." A free-way space of two millimeters at the region of the bicuspid teeth is the minimum which is necessary for the proper rest of the supporting tissues of denture bases. Measurements made from reference points on the face would be correspondingly greater.

The vertical dimension of occlusion is the vertical separation of the two jaws that exists when teeth are in occlusal contact. This is the vertical dimension which is of importance to prosthodontists because it is the degree of jaw separation which must be determined for the arrangement of teeth. It is the vertical dimension which must be established on the articulator. This vertical dimension must be less than the vertical dimension of rest position.

The vertical dimension of occlusion is developed when stops are inserted between the mandibular and maxillary ridges. These stops consist of teeth, and the alveolar ridges when the natural dentition is in place. The stops consist of the teeth, the denture bases, and the remnants of the alveolar ridges after the natural teeth are lost. The denture height compensates for the loss of the natural teeth and the loss of the alveolar ridge structure. The denture height is sometimes erroneously spoken of as the "height of the bite." The terms "height of the bite" and "denture space" should be eliminated because they do not specify reference points. The term *interalveolar space* of occlusion specifies the reference points and the jaw separation. The *interalveolar space* is the space available for dentures within the limits of the vertical dimension of occlusion.

CONCEPTS

Occlusion may be discussed from two viewpoints. It may be discussed in its static relations or in its dynamic relations. The static relations in occlusion are those which occur in the many possible contacts of teeth without the interposition of food. The dynamic or functional relations are those which occur in the mastication of food.

THE STATIC CONCEPT

The static relations in occlusion include centric occlusion, protrusive occlusion, right and left lateral occlusion, and intermediate occlusion. All of these occlusions should be balanced with simultaneous contacts of the teeth on both sides of the arch and front and back at their very first contact. The cuspal inclines should be developed so the teeth *can* glide from one basic position to another without interference, and without the introduction of rotating or tipping forces. All of these tooth relations must be in harmony with the activity in the temporomandibular joint and with the musculature.

Perfect intercuspation (of cusp teeth) should exist in centric occlusion. The teeth should be in centric occlusion in the mouth when the teeth first contact, and when the jaws are closed in centric relation.

Perfect intercuspation (of cusp teeth) should exist in the lateral occlusions on the working side. This is necessary to prevent the rotation of the denture bases in

relation to their foundations. At the same time, a balancing contact should be developed on the balancing side to prevent tipping of the dentures.

Protrusive occlusion requires that simultaneous contacts be made on the anterior teeth and on the last molars.

The intermediate occlusal contacts should maintain the same bilateral balance and be free of cuspal interferences.

The purpose of balanced occlusion is to eliminate forces which tend to dislodge the denture bases from the supporting ridges. In order for balanced occlusion to be effective in the mouth, the cast relations and guidances on the articulator must duplicate the jaw relations and guidances in the mouth. None of the existing articulators can do this in all relations with complete accuracy. Some articulators are accurate at the relations recorded in the mouth, but are inaccurate at the intermediate occlusion. Most articulators do not duplicate the Bennett movement.

The *Bennett movement* of the mandible changes the paths of the cusps of the working side from simple arcs around the lateral rotation center at the condyle to arcs with a larger radius. This frequently causes teeth which have perfect intercuspation in lateral protrusion on the articulator to be out of harmony with each other when they are in lateral protrusion in the mouth. This causes the denture bases to tend to rotate on their foundations.

Most prosthodontists agree that the damage caused by inadequately balanced occlusion is done when no food is in the mouth. They feel that disharmony of occlusion causes the patient to make many extra closures. The attendant skidding of the denture bases on the ridges causes the damage to the supporting tissues.

Bilateral balanced occlusion is effective also in the mastication of food. When food is placed on the working occlusal surface on the working side and pressure is applied, the soft tissues that support the denture bases are displaced toward the bones on that side. As the bolus of food is penetrated, the teeth on the balancing side make contact with each other before those on the working side make contact. This prevents the tipping of the dentures during the final part of the masticatory stroke. The hardest pressures are applied in the final part of the masticatory stroke, after the teeth of the working side are nearly in contact. It is at this point that balanced occlusion is needed most.

THE DYNAMIC CONCEPT

The dynamic concept of occlusion differs from the static concept in that it is primarily concerned with opening and closing movements involved in mastication, while the static concept of occlusion is concerned primarily with tooth contacts made at various positions. In this concept, the jaw movements and tooth contacts that are made as the teeth of one jaw glide over the teeth of the opposing jaw are not functional movements or contacts. This phase of occlusion is admitted to be controlled by the temporomandibular joints, the muscles and ligaments, and the teeth. Movements of the mandible which occur when the teeth are not in contact are classed as free movements.

Functional or chewing movements are distinguished from the glide of one set of teeth over the other, except at centric occlusion. The functional movements are

the movements of the lower teeth as they approach the upper teeth in the chewing cycle. The chewing cycle involves the direction of approach of the upper teeth by the lower teeth but ending at centric occlusion. The direction of this closure is influenced by several factors. The temporomandibular joint, the occlusal form of the teeth, the occlusal plane, and others have been mentioned. The musculature and the timing of the contraction and relaxation of the various muscles is obviously very important. The resistance of the food and the relative tolerance of the supporting tissues are also vital factors in the chewing cycle.

Most authors agree that the more nearly vertical the forces are applied to the foundation of the denture bases the more favorable they are. The position the jaw is in when the closing forces are applied will determine, to a large extent, the resultant of the applied forces. This may be modified by the occlusal form of the teeth.

The opening (and closing) movement of the jaw has been a subject of considerable discussion. It is involved in the construction of dentures, but in relation to occlusion, clearance for lower cusps to pass over upper cusps without interference when the mandible is maintained at its most retruded position is of equal importance. If this clearance is not provided for, horizontal thrusts are applied on the denture.

CONCLUSIONS

The existing concepts of occlusion in prosthodontics may be summarized as follows:

1. There is a definite and serious need for a more uniform terminology.

2. Terminology should be so designed that it will provide the necessary "handles" for ideas and situations in prosthodontics.

3. There are four components of occlusion. The temporomandibular joint, the musculature, the tissue support for denture bases, and the teeth. Only the last of these is completely in the control of the prosthodontist.

4. The temporomandibular joint is capable of varied and complex movements. Some of the movements are controlled by guiding influences of the joint and the occlusal surfaces of the teeth while they are in contact. Other movements are the free movements that are controlled by the neuromuscular system, and the guiding influences of the temporomandibular joint. These are the movements that occur in the mastication of food and in speech.

5. The musculature supplies the power for occlusion in the direction of the contracting fibers which varies with the position of the mandible when the contraction occurs.

6. The soft tissues in the basal seat of dentures contribute to changes in the relative positions of the bones (of the maxilla and mandible) to each other when varying pressures are applied.

7. The occluding surfaces of teeth serve as guiding influences on jaw movement when they are in contact, and determine to a large extent the cycle of jaw movement used in the mastication of food.

8. The arrangement of the contacting surfaces of teeth to each other in varying jaw positions influences the relation or stability of the dentures to the basal seat.

9. An understanding of the static concept of occlusion is necessary for the proper arrangement of teeth.

10. An understanding of the dynamic concept of occlusion is necessary for the development of an efficient masticatory apparatus.

11. The static concept of occlusion applies when there is no food interposed between the teeth, while the dynamic concept of occlusion applies when the mastication of food is being accomplished.

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A CENTER-BEARING TRACING TABLE FOR PARTIALLY EDENTULOUS MOUTHS

Temporary crowns are waxed up on dies leaving a hole in occlusal surfaces and having a 1½ by 3 mm. ledge or lug between the occlusal surface and the gum line to support a brass plate to which the lugs are to be soft-soldered. Seat the temporary crowns on a duplicate of the master cast. Press a piece of 0.003 tin foil lightly on the occlusal surfaces of this cast until indentations are showing in the foil. Carefully cut these indentations out with fine scissors, until the foil will just slip over the teeth and rest on the lugs on the temporary crowns. This tin-foil pattern is then laid on a piece of 12-gauge half hard brass plate, and the holes to be cut out are scribed carefully in the brass. Be sure to keep at least ⅛ inch leeway on the buccal, and to extend a piece at median center, which will allow the fastening of a Thompson cross bar clamp. This may be modified to accommodate any other extraoral tracing device the operator might choose. Either drill or cut out the holes, as scribed on the brass plate, with a metal saw. Make sure that the brass plate goes to place on the crowns on the cast as did the foil. Then soft solder the brass plate to the lugs on the crowns while it is on the cast.

To facilitate an easy tracing motion, cut a 1 inch square of thin stainless steel shim metal, and lay it in the palatal brass plate. Drill a small hole with a bur in each corner of the steel shim, and through the brass plate. Use ordinary brass pins in the holes to hold the shim steel, leaving the heads on the pins. You may also wax the plate onto the brass plate, or cement it with Dupont cement. The center of the lower brass plate is drilled with a No. 40 drill, and tapped with a 4-40 tap. Make 3 or 4 such holes about ⅛ inch apart on median line; use a 4-40 brass screw for the center bearing pin; taper it to a rounded point.

—Arthur E. Aull

A COMPLETE STANDARDIZED PRE-EXTRACTION RECORD

HOWARD J. MERKELEY, D.D.S., M.D.S.

Winnipeg, Manitoba

MORE AND MORE it is being recognized that to extract all the teeth without having first made a record of facial contours, tooth size, color, and arrangements, etc., is almost criminal.

For many years we have made records, and from time to time have added steps as the necessity for a more complete record became evident. The following system is thus the fruit of many years' effort. The record is very easily made, and also very impressive to the patient, as he at once realizes the effort made on his behalf. In fact, many patients now present themselves requesting this service, even though they do not anticipate a complete extraction for some years.

THE PROFILE RECORD

A piece of 16 English gauge galvanized iron wire about nine inches long has an elongated, flattened loop made at one end. We lay the loop end against the forehead and proceed to bend the wire to the facial contour, midline, teeth occluded in centric. We proceed from the glabella down the nose, using the fingers to bend the wire, with the help of small pliers if necessary. We use round beaked pliers so the wire will not be marred. Under the chin, we terminate the wire in a small loop. Adjusting the profile wire to the face, we next register the position of the incisal edges of the upper teeth by a circumferential groove made with a pair of side-cutting pliers. With a pencil, we draw a line on the labial surfaces of the lower central incisors at the level of the upper incisal edges, with the teeth in centric occlusion. Then measuring this vertical overlap, we make another circumferential groove to denote the position of the incisal edge of the lower incisors. This will be above the groove already made when a vertical overlap exists. With the patient sounding SISS, SISS, a number of times, we note position of the incisal edges of the lower teeth, and make a small nick on the labial side of the wire at this level. To preserve this record, we mount it on a piece of balsa wood 8 or 9 inches long and 2 inches wide and ⅛ inch thick. A name tag is attached to the wire by winding a piece of one-half inch wide adhesive tape around the flattened loop at the top of the wire. It is wound around the loop to lie flat against the paddle. The name is written on it and it is covered with Scotch tape. The profile wire is laid on the balsa paddle with the nose outline pointing to the right.

A pencil mark in each loop is used to locate the spots where a daub of hot compound is stuck to the balsa wood. The wire loops are coated with Vaseline and

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pressed into the warm compound. The wire is removed when the compound is cool. We can thus relate the wire to the balsa paddle at any time. The wire is outlined on the wood and the incisal numbers 1, 2, and 3 are marked on the balsa paddle in the incisor area. We are now ready to relate a cast of the right upper and lower teeth in centric occlusion, to the profile wire.

PRE-EXTRACTION CASTS

Two simple aluminum trays are made. One is a flat piece of aluminum with a flat piece projecting at a right angle for a handle. The other is a flat piece of aluminum bent in the middle at a right angle with the smaller end narrowed where it joins the other half, and the end made circular for a handle. The trays are perforated to give attachment to the impression material.

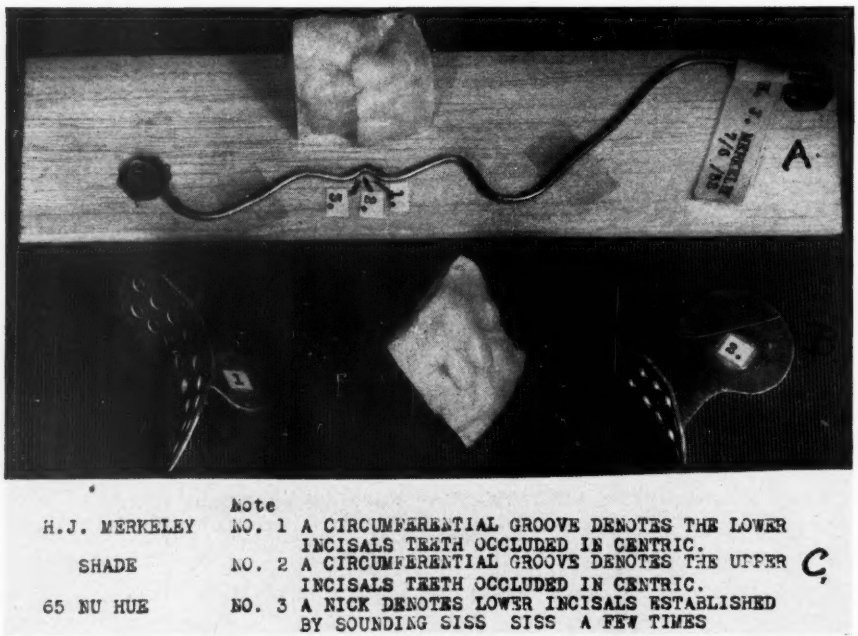
A.
1
2.
Note
H.J. MERKELEY
NO. 1 A CIRCUMFERENTIAL GROOVE DENOTES THE LOWER INCISALS TEETH OCCLUDED IN CENTRIC.
SHADE
NO. 2 A CIRCUMFERENTIAL GROOVE DENOTES THE UPPER INCISALS TEETH OCCLUDED IN CENTRIC.
C.
65 NU HUE
NO. 3 A NICK DENOTES LOWER INCISALS ESTABLISHED BY SOUNDING SISS SISS A FEW TIMES

Fig. 1.—*A*, Profile record on a balsa paddle. *B*, Trays and cast of the left anterior teeth. The cast can be accurately related to the right half. *C*, The information on the reverse side of the balsa paddle.

Using the second tray, we make a labial impression of the right anterior upper and lower teeth in centric occlusion. The handle is positioned so it is continuous with the median line. It is poured up in plaster. The tray handle is laid flat to the base it is being poured on, so the cast will show a flat surface corresponding to the median line of the palate. We will later relate the left anterior cast to this with dowels. The median line end is trimmed until it conforms to the palatal median line. Two holes are bored in this surface, and two pin heads are inserted. The pin shanks are shortened so they will project three-sixteenths of an inch from

the plaster cast. The pins are fastened with sticky wax with the heads buried. An X groove is cut into this surface and the entire surface is coated with soap.

A bilateral labial impression is made in an alginate impression material with the teeth in centric occlusion in tray number one. The poured cast of the right side is related to its place in the impression and held in place firmly while the left side of the impression is poured. When this is set, it is removed and the right and left sections are separated. The sections can be reassembled very readily.

Next, we use the second tray and an alginate impression material to make another right side thin impression. Any alginate covering the left incisors is cut off so the impression is flush with the median line. The impression is removed and the lingual side is trimmed to the median line also. The impression is reinserted into the mouth, and the profile wire is put against the face to the left of the tray handle. This is held firmly in place and the tray handle is fastened to the profile wire with a drop of sticky wax. The impression and wire are removed en masse and the right side cast is placed in the impression. The daubs of compound on the balsa wood are used as guides to center the loops in their grooves and the cast is gently pushed down. The pins will punch into the wood, and so fix the relation of the teeth to the profile wire. The cast can be removed at will, and assembled with the left section to give us a record of all of the anterior teeth. The dowels serve to relate the left and right sections of the labial cast accurately.

When the dentures are completed the patient is given the balsa wood paddle with the profile wire and cast (Fig. 1). The reverse side of the paddle carries the date, the name of the patient, shade of the teeth, and the explanation of the rest relation. Scotch tape holds the profile wire to the balsa wood paddle. The paddle is placed in a manila envelope, the face of which carries printing as follows:—

VALUABLE

PROPERTY OF .....

Date .....

DO NOT BEND

Preserve this profile wire. It is the only record of your natural profile. Take it to your dentist every three or four years, and he can check with it and adjust your dentures if necessary, to restore your normal youthful profile.

Dr. H. J. Merkeley

This record gives us the vertical dimension, the facial contour in the median line, the tooth arrangement, tooth shape, size, shade, and incisal overlap, as well as any peculiarities and arch width.

The time consumed in making this record is really very short, in terms of its value.

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TROUBLE SHOOTING IN FULL DENTURE CONSTRUCTION

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THERE ARE TWO major causes for faulty denture construction. One is the dentist who disregards the fact that he is dealing with living, functioning tissue. The other is the laboratories which violate the mechanical principles involved in full denture construction. The results are beautiful dentures that fail to work properly.

It is not the purpose of this article to discuss the factors involved in the construction of full dentures, but to analyze the troubles encountered after they have been made and delivered to the patient. It is assumed that the operator has endeavored to follow the principles of good denture construction.

1. Poor retention when the denture is first inserted. This is usually due to excess saliva. The new dentures act as a foreign body and stimulate the salivary glands so they secrete an abnormal amount of saliva. This should be expected when the patient is wearing dentures for the first time, and usually clears up in three or four days.

2. The upper denture drops when the patient yawns.
   a. During the act of yawning the mouth is opened to its fullest extent, and the border tissues pull down against the borders of the denture. If there is an area of irritation, the borders are overextended, and should be reduced. If there is no evidence that the borders are overextended, the patient should be cautioned to refrain from opening the mouth too wide.
   b. The buccal flanges of the denture may be too thick so they interfere with the action of the ramus. A side-to-side movement of the jaw will loosen the denture. If this occurs, reduce the thickness of the distal ends of the buccal flanges.
   c. The occlusion is not balanced. When the patient closes in centric position, the denture tends to be unseated by the faulty occlusion of the teeth.
   d. The denture is extended too far back on the soft palate. During the act of swallowing, the soft palate moves up and down, and if the denture is too far back, pressure is applied against the posterior border of the denture by the functional movement of the tissues, which tends to unseat the denture. One must remember that the extent to which a denture can extend onto the soft palate is determined by the throat form and the functional activity of the tissues.

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e. The denture is inadequately post dammed. Failure to post dam sufficiently means a poor postpalatal seal, and air is permitted to enter under the posterior border of the denture with a resultant loss of retention.

f. The buccal surfaces of the teeth are placed too far toward the cheek. When this occurs, the teeth are outside the basal seat of the denture, and when the mouth is opened, the muscles of the cheek pull against the buccal surfaces of the teeth and tend to unseat the denture.

g. The denture is overextended in the pterygomaxillary notch. When this occurs, the functional activity of the pterygomandibular raphé is interfered with, and during the jaw movements the denture is unseated.

3. The lower denture rises with wide opening of the mouth.
   a. The occlusion is not balanced (see 2, b).
   b. There is overextension of the buccal margins of the denture at the buccal frenum. Since this overextension interferes with the functional activity of the frenum, it lifts the denture up whenever it is pulled taut.
   c. The anterior teeth are set too far to the labial side of the ridge. This means that the anterior teeth are outside of the denture area, and the lower lip exerts more force against them than it normally should.
   d. The patient opens the mouth wide and pulls the tongue back. This causes the lingual frenum to pull up and unseat the denture.
   e. The lingual flanges are overextended onto the mylohyoid muscles. As these muscles function, they rise and fall, and if the denture flange extends upon them, the denture will be unseated.

4. The upper denture drops while singing.
   a. During the act of singing the mouth becomes dry, and the thin film of moisture required for retention is not present.
   b. Nervousness. Most people are nervous when appearing before the public, and this causes a decrease in flow of saliva, so that there is insufficient salivary flow for the retention of the denture.

5. The lower denture rises when the mouth is only partially open.
   a. The occlusion is not balanced (see 2, b).
   b. The lingual flanges are overextended in the mylohyoid region (see 3, e).
   c. The molar teeth are too far to the lingual. This causes a narrowing of the tongue space, and the tongue will cause the dentures to become unseated.
   d. The lingual surface of the denture is overcontoured (cupped out). This allows the tongue to fit in these depressions with sufficient leverage to cause the denture to rise. This may be avoided by forming flat lingual flanges.
   e. Overextension of the buccal flanges.

6. The lower denture unseats with various tongue movements.
   a. The lingual margins are overextended which interferes with the functional movements of the tongue. When the tongue is moved to the

right, and the left side lifts, the lingual flange on the left is over-extended. The tissues rise on the side opposite the direction the tongue is moved.

7. The upper denture drops while the patient is talking.
   a. Unbalanced occlusion is the main cause. A person wearing dentures unconsciously closes in centric occlusion to reseat his dentures, and if the occlusion is not balanced, he fails to seat them firmly.
   b. Poor border seal. This allows air to get under the denture and results in loss of retention.
   c. Inadequate post dam (see 2, d).

8. The upper denture loosens while whistling.
   a. This is caused by overextension at the labial or buccal frenum. During whistling, these frenum attachments are stretched taut so they pull down upon the denture if their free movement is interefered with.
   b. Inadequate post dam.

9. The upper denture loosens during laughing.
   a. Unbalanced occlusion (see 2,b).
   b. Underextended denture flanges which result in a poor border seal.
   c. Inadequate post dam.

10. There is more soreness under the lower than the upper denture.
   a. The maxillary denture covers a larger area than the mandibular, the load is distributed over a greater surface, and the smaller area of the mandible means that it must carry a proportionately heavier load.
   b. The maxillary denture is supported by a relatively fixed surface of immovable bone.
   c. The investing tissues of the mandible are thinner than those of the maxilla.
   d. The mandibular ridge is sharper and more irregular.
   e. There is less stability of the lower denture which permits it to slide and move more than the upper denture.

11. The patient gags.
   a. Overextension onto the soft palate. Some patients are extremely sensitive and cannot tolerate a denture border extending onto the soft palate.
   b. The upper denture is inadequately post dammed. The denture does not have a perfect seal and becomes loose, which causes a tickling of the palate, and the patient gags.
   c. Unbalanced occlusion which tends to loosen the upper denture.

12. Cheek biting.
   a. Prolonged absence of posterior teeth which causes the cheeks to thicken. This may be corrected by the use of bucal plumpers made of modeling compound on the maxillary denture. They will cause sufficient atrophy

of the tissues in a week or two to prevent biting the cheek, and then it can be scraped off.

b. Lack of sufficient horizontal overlap of the maxillary bicuspids and molars. This allows the buccal tissues to come between the upper and lower teeth due to the lack of the protective horizontal overlap of the upper posterior teeth. Reduce the width of the lower buccal cusps from the buccal to increase the horizontal overlap.

13. The lower denture kicks up during incision.
    a. Unbalanced occlusion. The posterior teeth are not in contact during incision, and sufficient leverage is exerted to cause the distal ends of the lower denture to rise.
    b. The anterior teeth are set off the ridge labially.

14. Insufficient tongue space.
    a. Broadening of the tongue due to prolonged absence of teeth. When the natural teeth are lost, the tongue spreads out because it is no longer confined to a small space. Usually the tongue will assume its normal size and shape when dentures are worn for a short time.
    b. The posterior teeth are set too far to the lingual. This creates a smaller area for the tongue, and usually means that the teeth are not on the ridge where they should be.
    c. The lingual flanges are too thick. Extremely thick denture flanges lessen the space which rightfully belongs to the tongue.

15. Dentures alternately loose and tight.
    a. This is usually due to dehydration, and it most often occurs in the afternoon. It can usually be traced to the physical condition of the patient or to the type of work he does. By having the patient drink a large glass of water, this condition is alleviated.
    b. Unbalanced occlusion.

According to Anthony[1] those factors which influence retention are:

1. Certain purely physical forces.
    a. Adhesion.
    b. Atmospheric pressure.
    c. Gravity.
2. Correct denture outline and contours.
3. Correct occlusion and articulation of the artificial teeth.

Of these, the last two are of the greatest importance, because most denture failures can be traced directly to them. If the dentist will recognize the anatomic and physiologic factors involved, he will secure the correct denture outline and contour. If the mechanical principles are followed, correct occlusion and articulation of the teeth will result. The successful prosthodontist is one who recognizes these principles and incorporates them in his work.

Swenson[2] effectively sums this up by stating, "No fine construction in any field can be attained without the engineer's knowledge of all that pertains to the building of the finished product."

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HIGH EXPANSION SOLDERING INVESTMENT

Equal weights of Cristobalite inlay investment and Weinstein's No. 3 investment make a rapid setting and very accurate soldering investment. When preheated, it seldom cracks.

—Clarence H. Blanchard

CHECK LINES ON PORCELAIN ANTERIOR TEETH

1. Select and blend colors to be fired from brown, black, gray, etc.
2. In a small ladle, melt ½ tsp. of pure paraffin and add the stain; mix and let it cool.
3. Grind the area to be stained with a heatless stone.
4. Flow the stain and wax combination on the tooth with a waxing instrument.
5. The check line may be carved very easily to the exact size, shape, and intensity desired.
6. Apply De-bubblizer to the surface.
7. Fill in the ground area, and over stain with a 1600° F. glaze (SSW).
8. Insert the tooth slowly into the oven at 1300° F. with the pins covered by silex on the tray.
9. Fire at 1600° F. for five seconds and remove for cooling.
10. Result—a very simple method of controlling a check line. The stain impregnated wax may be used over and over. The check line may be given the appearance of spreading by adding light amounts of the stain to the glaze while it is still moist, and vibrating slightly.

—Robert F. Brigante

SOME PSYCHOLOGIC ASPECTS OF DENTURE-STIMULATED GAGGING

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ONE OF THE important phases of prosthetic dental treatment is the adjustment of patients to dentures. A denture can be well constructed, nicely adjusted to the mouth, and well within the physiologic limits of the patient, and still be a failure. Most dentists at one time or another have observed patients who have failed to adjust to dentures or who have only partially adjusted to them. Some dentists have a tendency to refer to these patients as "cranks" because they take so much time with complaints and requests for modifications that seem unnecessary. These requested adjustments may well be unnecessary from a physiologic, mechanical, or esthetic standpoint, but still the patients insist that something is wrong.

One of the causes for failure is gagging. Fortunately, complete failure because of gagging is rather infrequent, and often can be traced to a tangible cause such as a post dam that exerts insufficient pressure on the soft palate or one that is placed too far posteriorly. This condition will tickle the soft palate (when the patient makes "ah" sounds) and stimulate a sensitive gag reflex. Fortunately, this condition is easily corrected by modifying the denture.

In a few instances where the post dam is correct, a patient will gag persistently when the denture is inserted. Some dentists merely attribute this to a sensitive gag reflex without looking further, but unfortunately, many dentists look no further than the mouth in their treatment of a patient. When gagging cannot be lessened by adjustments to the dentures, it is important to attempt to discover what other factors may be contributing to this condition. In dentistry, as in other fields of medical science, it is of the utmost importance to evaluate the patient as a total functioning unit, and not merely within one's own special field of interest. When such a point of view is taken, we see some of the dynamic forces operating in the individual which, in a large measure, govern his reactions to his environment, not only from a physiologic standpoint, but from a psychologic standpoint as well. The implications for prevention of damaging and uneconomical adjustments are at once obvious.

The opinions and conclusions contained herein are those of the writers and do not necessarily reflect the official views of the Department of the Navy nor of the Department of Defense.

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EXAMINATIONS

In order to learn more about some of the dynamic forces operating in individuals having various prosthetic difficulties, it was decided to enlist the aid of diagnostic psychologic examinations.* This article will consider results from three dental patients tentatively diagnosed as "psychologic gaggers." A family and medical history was taken, and pertinent aspects will be presented in the case studies to follow.

CASE 1.—A male patient 43 years old, was unable to wear complete dentures because of gagging. Looking into his past history we find that during the war he made a short cruise on a Navy ship as the ship's barber, and because of the motion of the ship he hit his head. He claimed that this caused constant headaches, and he could not see as well as he could before the accident. During his hospitalization, partial dentures were constructed which he later claimed caused the loss of the abutment teeth. Upon examination, the headaches and partial loss of sight could not be attributed to organic causes. He was subsequently retired and sent to a veterans hospital for further treatment. Here he was given psychotherapy, but this did not relieve his symptoms. His remaining teeth were then extracted to rule out possible foci of infection, and complete dentures were constructed for him. He wore the dentures successfully for three days, then some of his friends disapproved of them esthetically and he started to gag. From then on he was able to wear only the maxillary denture, and then only when he chewed gum.

This patient feels that a satisfactory denture cannot be made for him unless a Vitalium implant is used to stabilize the lower denture. If this is done he knows he will not gag. He insists that he will not be able to wear another conventional denture. He presents anatomically well-rounded ridges, and an implant is contraindicated.

He said, "I am going to fight you every turn in making the denture." Outwardly he is cooperative.

This patient owns his own barber shop and employs as many as seven barbers. He claims he likes being a barber because in the shop he makes contacts through which he can practice his hobby. His hobby is entertaining sick children, and he does this by visiting various children's hospitals dressed as a clown.

Looking into his family history we find some sociologic predisposing factors contributing to his maladjustment. He came from a family of Polish immigrants. His mother and father were both barbers who made a somewhat inadequate living. He was required to leave school to help financially before he completed his education. His mother was the dominating figure in his home and always had the final word when decisions were made. He had one older sister and a younger brother. His father died when he was 20 years of age; and he left home three years later to become a hobo.

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*Included in the psychologic examinations were the Rorschach Ink Blot Test[1] and the Thematic Apperception Test (TAT)[2]. The Rorschach Test is a widely used psychologic test which reveals aspects of the personality at deeper levels which are important in explaining his overt behavior. The TAT is composed of a series of pictures, rather hazily drawn and presented to the patient, who makes up stories about the pictures. The stories patients create reflect their own needs and inadequacies as based on their past experiences and on their fantasies. Both are designed to get at factors of which the patient is not necessarily aware, but which influence his behavior.

The psychologic tests were interpreted without knowledge of the patient's family background or condition. Psychologically, the over-all picture is one of an individual characterized by intense feelings of insecurity and inadequacy. There are strong aggressive impulses which he is unable to handle adequately in a socially acceptable fashion. Anxiety thus engendered is held in, and the patient is not able to express this inner psychic tension directly. Strong feelings of guilt and self-destruction are present and are expressed clinically in statements as "you could cut my whole throat and I wouldn't care," and "if I find the pleasure to gag, I will gag." His basic exaggerated need for love and affection underlies his entire behavior. He has not been able to accept these feelings and needs on a mature level, and thus has regressed to modes of expression of a more infantile level. There is a strong predisposition to psychosomatic affection, but as yet it does not seem to be crystallized clearly.

Discussion.—We have seen, through a psychologic examination of the life history of this patient, some of the more dominant needs and conflicts still operating within him which help to explain his present inability to adjust to dentures.

Early in the patient's development was a very strong, overpowering mother who was demanding, yet did not give the warmth, support, and affection needed in early formative years. The father, being a rather weak, passive, and inadequate person who was dominated by his wife, did not provide the patient with the type of security nor type of authority relations which are characteristic of masculine development in American culture. As a result of his close attachment to his strong, dominating mother, feelings of guilt were developed. Coupled with the guilt feelings were both hostility and aggression toward the mother which had to be repressed since they could not be expressed. Along with these was a need for self-punishment for such feelings. As a result of the still unresolved conflicts, the patient as an adult presents difficulties in four main, but highly interrelated areas: (1) exaggerated problems with authority figures and with authority relationships, (2) over-dependency needs, (3) an exaggerated need for love and affection, and (4) unacceptable methods for handling his strong aggressive and hostile impulses.

In the light of these psychologic forces, the bases for his difficulty in adjusting to dentures become apparent. The dentist as an authoritarian figure for the moment fulfills a need for a strong dominant father substitute which his father, because of his own inadequacies, was unable to fill. Previously, the period in the Navy partially satisfied his dependency needs. It has been shown previously that both healthy and maladjusted young men in the Navy demonstrate over-dependency needs, and it has been suggested that perhaps the Navy provides a protective environment for such persons. However, there is a difference in the manner in which the healthy and maladjusted handle these needs.[8] In the Navy, where authority relationships are more clearly defined than in civilian life, he was unable to accept authority, even though his desires were strong, and thus he retreated to a more carefully protected environment—that of the hospital, which might also help to fulfill his needs for the first three of his four main conflict areas.

The attention which he receives from the dentist also partially fulfills his need for attention and symbolically for affection. "I am going to fight you every turn

in making the dentures," expresses not only his defiance of the authority figure, but reveals his resistance at the threat of the removal of the "beloved symptom" as well. As long as the dentist is satisfying the patient's neurotic need for attention and defiance of authority, and he can remain dissatisfied with the denture, it is not likely that any dentist will be able to make an entirely satisfactory one.

His desire for an implant is possibly related to his desire for surgery—for punishment for his very strong guilt feelings. If an implant were made for him, and if he really accepted the fact that this was the last thing that could be done, his gagging might possibly stop. If he could accept this he would then have closed an avenue for the satisfaction of his neurotic needs and would no longer have a reason to go to the dentist. He would then have to seek fulfillment of his unresolved needs in another manner.

CASE 2.—The second patient is a man 51 years old who had all his teeth extracted in 1944 and has had difficulties with maxillary dentures because of gagging. He feels that his teeth should not have been extracted, and he feels that his first set of dentures was poorly made and did not fit properly. He could keep them in for only five minutes at a time because of gagging. In 1946 another set was made which proved to be somewhat better than the first one. He learned to wear them for about a half hour, but then had to remove them because of gagging.

His present dentures were constructed after one-half cubic centimeter of 95 per cent ethyl alcohol was injected into the area of the posterior palatine foramina.[4] He says he is ordinarily able to keep them in for nine hours, and that if his "mind is at rest" he can keep them in for twenty-four hours.

On the surface, this man is a very cooperative patient and does everything that he is told. He claims that he is well pleased with his present dentures, but that his wife and friends tell him they are not as good esthetically as they might be. He feels that perhaps his mouth lost part of its natural shape because he had been without teeth for so long. Examination showed the replacements to be quite satisfactory functionally, and it is felt that a good esthetic result was obtained.

This patient is very much concerned about his state of unemployment. He feels that he is a politician and is at odds with the mayor of his city and, for this reason, is unable to obtain employment.

Psychologic testing revealed the patient to be primarily an obsessive-compulsive personality, and revealed the neurosis to be well developed and of long standing. The Rorschach showed a marked phobic process and the personality to be characterized by its ruminative nature. There were further indications of a paranoid type of thinking in the record. A TAT was not available.

This is the patient who is punctual and always keeps his appointments and, as Beck states, "they are as predictable as the movements of the planets."[5] The obsessive neurotic has developed fixed reactions and cannot tolerate changes in his environment. The idea of losing his teeth and adjusting to new dentures presents an overwhelming threat to his ego, and denture difficulties represent such an insurmountable obstacle to adjustment.

CASE 3.—The third patient was a young enlisted man, 22 years of age, on active duty in the Navy. A mandibular partial denture was constructed for him replacing the lower left first and second molars. The completed denture was inserted and worn successfully for about five hours. After completing his evening meal he removed the replacement to clean it and found that he could not put it back in his mouth without gagging. His mouth was examined and no mechanical irritation could be found. The patient was very cooperative during treatment.

This patient was assigned to a job which he didn't like. He thought the job was below his ability, and that he could do a day's work in about two hours. He spent the rest of the working day in the ship's store until a station order was issued closing the store during this part of the day. He then had nothing to do with his free time. He was recently married, and was required to stand a watch every fourth night on the Naval station and could not be with his wife. He could not understand the reason for his standing this watch as there was nothing for him to do.

His job was then changed to one that required his working a full day, and he was not required to stand any after-hour watches. He could go home every night and had every week-end off. The gagging then stopped and he could wear the denture comfortably except when he became over-tired from athletics. At these times it was necessary for him to remove it because of gagging.

His mother wears complete dentures which always gagged her. She was never able to wear the maxillary and mandibular dentures together, but could wear either one or the other. Because of his mother's inability to wear dentures, the patient feared he would not be able to wear his replacement even before it had been constructed.

The Rorschach test revealed primarily a very inflexible, rigid personality structure—one not permissive of change. There is much anxiety present at a deep level which prevents the patient from enjoying pleasurably-toned stimuli. Most of the ego's energy is utilized in keeping the anxiety from breaking through. The ego thus maintains an eternal vigilance at a high cost to total personality functioning. There are few outlets; recourse to fantasy living is present but greatly subdued. The personality portrayed here is characterized by its over-all inner psychic constriction and conscious control, lacking in richness and spontaneity, typical again of the obsessive neurotic.

Stories in the TAT were characterized by a general theme of hopelessness and worthlessness together with a notable lack of ambition strivings. There is, however, some adolescent day-dreaming which substitutes for the low level of need for achievement. There is considerable hostility directed toward maternal figures, probably emanating from his feelings toward his own mother. There are also strong guilt feelings elicited.

This patient differs somewhat from the first patient in that he does not have as strongly defined resentment toward male authority. There is also not as much intensity invested in his feelings. There is less likelihood he would become dependent on the dentist, or direct hostility toward him through his reactions to the dentures.

He does not have as strong an overdeveloped desire for approval as was demonstrated by the first patient. It is quite possible that his disorder would never have come to the dentist's attention, for if the gagging were to continue due to his lack of adjustment to situations in general, the replacement would very likely have become a "bureau drawer" piece. Further, it is probable that this patient's

initial inability to wear his replacement was directed to gagging because of his close attachment to his mother and to an identification with her—it was thus expressed directly in a similar dental difficulty. The denture difficulty does, however, serve a useful purpose to the patient and reflects his strong dependency on his mother and, at the same time, his feelings of antagonism toward her.

SUMMARY AND CONCLUSIONS

In an extensive examination of three dental patients we find that gagging stimulated by dentures has important psychologic implications. When dentures cannot be adjusted to the patient's satisfaction, it is important to look for possible emotional advantages which the condition may be offering the patient. The gagging and the resultant inability to wear dentures seems to serve a worthwhile purpose for the patient; he receives a "secondary gain" from the disorder. It might be well to reiterate how these patients' neurotic needs were being met by their relations with the dentist.

Problems emanating from the inability to cope with authority relationships were prevalent in one patient. His feelings were thus transferred to the dentist. In another, an overcompliance and submissiveness to the dentist was apparent, and in the third patient an overdependency on the mother resulted in dental difficulties similar to those of the mother.

While no one may be completely adjusted to his environment, we found our three patients to have emotional difficulties representing unresolved conflicts and unsatisfied needs which were so strong within the individuals that they seriously affected their interpersonal relations. As a group, our patients manifested an excessive amount of anxiety which had not been channeled into more useful activities.

In all three patients a well-delineated neurotic process was present; in only one could the neurosis *not* be said to be debilitating. Because of this patient's youth, there may still be a fundamental personality change, although at present the prognosis is not too promising.

In view of these findings, we may emphasize the importance of the patient-dentist relationship, for in our three patients a symbiotic one was well established which was not conducive to the patients' future welfare. The dentist must be aware of such needs even though he is not always equipped to cope with them.

In some cases where a trigger zone can be demonstrated, there seems to be the possibility of treating a gagger by therapeutic means (alcohol injection of the sensory nerves).

While this study was primarily concerned with psychologically induced gagging, it is strongly felt that other difficulties in adjusting to dentures from a physiologic, mechanical or esthetic standpoint, may be closely related to the patient's psychologic state, and that further studies are necessary.

It is not probable that psychologic testing could predict in advance those who would be potential "psychologic gaggers," but the general adjustment of the patient is easily detected by these examinations and the reasons for maladjustment can usually be demonstrated. It is further possible that in those persons with certain types of maladjustments, there will be more than average difficulty in adjusting to dentures.

The authors acknowledge the cooperation of Dr. I. R. Hardy and Dr. A. Yurkstas of Tufts College Dental School for furnishing two of the patients presented.

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TO LOCATE THE PTERYGOMAXILLARY NOTCH

Solder a ten cent piece on a stem of an old mouth mirror. The ten cent piece is serrated on its periphery, and therefore will hold indelible pigment when an indelible pencil is rubbed over it. Rub the pencil on one side only. Place the unmarked side of the dime on the upper ridge, and run it posteriorly until it drops behind the tuberosity. Push it further back until it drops into the pterygomaxillary notch. The dime is thinner than the mouth mirror, and will drop more easily into the notch. By rotating the dime when it is in the notch, the indelible pigment held in the serrated portion of the periphery will mark the notch correctly.

—Saul C. Robinson

APPLIED PSYCHOLOGY, AN ESSENTIAL ADJUNCT IN SUCCESSFUL DENTURE SERVICE

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SUCCESSFUL denture service requires the coordination of technical skill with a knowledge of psychology to the extent that a prosthodontist is qualified to "mould the mind as well as fit the mouth." While the ability to produce good dentures is the primary requisite in attaining success, the ability to create a desire for such a service is of almost equal importance. The combination of these two qualities, unfortunately, is the inherent gift of but few men.

However, those in the dental profession who have heretofore assumed that technical knowledge is sufficient, and have only this knowledge, can acquire the second ability by applying basic psychology that is associated with ethical salesmanship. In writing on this subject, Bliss[1] stated: "The dentist has no desire to become a salesman as such, but certainly he should not ignore the lessons to be learned from this fine art of social service."

It is evident that some dentists regard prosthetic dentistry as a necessary evil in their practice. In many instances, those taking this attitude have been forced to do so because of the number of denture make-overs in their practices. These invariably result in an economic loss. Some of these men say they are unable to adopt a denture-making technique which would yield more satisfactory results, because it would be too time consuming for the monetary return involved in this service.

This is an intolerable situation. It is an admission that dentists are woefully lacking in their efforts to educate their patients to an appreciation of the highest type of denture service obtainable so they will demand it. The old adage, "Sweetness of low price has never overcome the bitterness of poor service," is as true today as it was one thousand years ago. It reflects the fact that people will pay well for what they want, and what they think is good for them.

A pleasing personality is one of the most valuable assets a dentist can have. Yet, within itself, it is an insufficient armamentarium with which to solve the problem of acceptance. Therefore, a pleasing personality must be combined with the art of making people want what is good for them, if its full advantages are to be realized.

In order better to effect the psychologic part of the procedures in denture service, it is necessary for the dentist to place himself in the position of the patient. When he does this, he will immediately realize that the loss of one's teeth is a major catastrophe in the life of an individual.

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In dealing with this subject, Bliss[2] remarked: "No doubt every dentist at various times has wondered just how it would feel to lose all of his teeth and be forced to wear dentures. If all dentists by some quirk of fate could serve an 'edentulous apprenticeship' there would be a remarkable change in their attitude toward denture patients. It then would be easier to understand exactly how people feel when that long-dreaded visit to the dentist can no longer be avoided. Seeing such things every day, the operator is likely to become callous and view each new case strictly as just one more set of dentures to be made. From the patient's viewpoint it is a most critical period when a final transformation must be made from youth to old age."

The varied emotional reactions a dentist encounters daily present a real challenge to a man who is inclined to be a humanitarian. They give the dentist an opportunity to be of comfort and service to his patients at a time when their spirits are at a very low ebb.

It is a certainty that kindness and understanding during these trying days engenders a spirit of loyalty and friendliness from patients. This situation should give a dentist a feeling of satisfaction that is more sustaining than any fee he has ever received. Many times one finds the expressions of gratitude from his patients to be a stimulating treatment for himself.

In successful denture service, it is essential that both the prosthodontist and the patient have a sincere desire to cooperate if their relations are to be carried out harmoniously, and if the job at hand is to be well done. It is also of primary importance that these two people have a clear understanding of what each expects of the other. At this point, it is well to remember that the ultimate expectations of the patient should never be permitted to reach beyond the capacity of the prosthodontist to produce.

To start work for an edentulous patient simply on the premise that he expresses a desire for dentures is an all too frequent procedure which can have an unpleasant ending. There are numerous well-planned questions that can be asked routinely, which will help to analyze the patient's desires and his mental attitude toward dentures.

Some questions suggested by Swenson[3] are "How is your general health? Are you a nervous person? Are you easily discouraged? How long have you worn your old dentures, if you have worn them? Were you pleased with your former ones? In what manner did they trouble you?"

An additional question the prosthodontist might ask is, "What do you expect of a set of dentures?" The answer could well be, "Oh, I only want something that stays in place, fits well, looks good, that I can eat with, and that doesn't make my mouth sore!" What this patient has said, no doubt sounds reasonable and adequate to himself, yet, it leaves a wide open avenue for dissension and dissatisfaction. For instance, the word "fit" can be construed so differently by each individual that when it is used in this manner it conveys absolutely nothing to the prosthodontist.

It is a good plan to let the patient do a great deal of the talking while the attempt is being made to size up his expectations and his demands. There is nothing more gratifying to a person than to let him know that you have a genuine, personal

interest in his problems. In most instances when this procedure is followed, and when conversation is induced in a diplomatic way, the patient will open up and tell enough to enable the dentist to make an accurate appraisal of him.

After analyzing the general attitude of a patient during this quiz period, the dentist should be able to determine the mental reactions and a great many of the patient's characteristics. It should be evident whether or not the patient is reasonable to the extent that by proper cooperation, the desired results in denture making could be obtained. If, after due consideration, the dentist is convinced that he is dealing with an uncooperative, unreasonable person, it would be wise to make his services unavailable to him.

Since there are no established rules on patient-dentist expectations, and their fulfillment, the time is now right to give this subject some serious thought.

An effort is being made in Charlotte, N. C., to determine what a patient should rightfully expect of his physician or dentist. A movement is under way by the medical and dental professions to see how well these reasonable expectations are being met, and how well they can be met.

The project is being sponsored by the Mecklenburg County Medical Society with the cooperation of the Charlotte Dental Society. It was spearheaded by a recent poll conducted on a local level. A questionnaire was sent to each physician and dentist in the city and county. These questionnaires were designed to garner pertinent information which would indicate the physicians' and dentists' concepts of "patient expectations and demands." Each respondent recorded what he thought a patient should rightfully expect of him. As a result of this study, an attempt is being made to see how well these expectations can be and are being met in Charlotte.

One might ask, "Why seek such information?" The answer is the awakening to the fact that indifferent attitudes toward patients by too many physicians and dentists has created a precarious situation for the professions in regard to socialized medicine and dentistry. It is fortunate that a few men of vision have instigated measures to cope with this situation before it is too late. It would be tragic to remove that incentive for knowledge and scientific advancement that has placed American medicine and dentistry in the spot of world-wide pre-eminence that they now occupy.

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PREMEDICATION IN PROSTHODONTICS

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THE ART AND SCIENCE of prosthodontics has become highly differentiated in our day, and more spectacular progress has been made in it than in any other dental specialty.

To render really satisfactory mouth rehabilitation service, the dentist must have thorough knowledge of anatomy, physiology, and physics, and should also possess engineering skill, and even physical strength. He has a long period of preparation behind him, but the work alone is not his only concern; there is also the human equation. Hippocrates[1] says: "All heads are different." They are—both inside and outside—and the dentist has to treat each accordingly.

Recently, Harold W. Dodds, the president of Princeton University, stated that we are living in an age of phenobarbital neurosis. The nerves of the average person often fail to adjust to the speed and too rapid progress of our present civilization, and it becomes difficult to cope with emergencies and painful experiences.

Nobody enjoys pain, physical or mental, and pain is by many people associated with dentistry, whether this stems from tales of the sufferings of others or from an unlucky previous experience of their own. Besides, trauma in the mouth seems to be more disturbing to people than trauma in any other part of the body. Local anesthesia is a known fact, but people distrust it, and they often dread the needle more than the actual operation, unreasonable as it seems.

There is, to many people, something disturbing about the aspects of the dental office with the strange chair and the unfamiliar, sometimes gruesome looking instruments. Another phase of this unhappy circle is the apprehension of the discomfort the patient expects: the helplessly open mouth, the dentist's fingers that stretch lips and cheeks unpleasantly, the presence in the mouth of sharp or boring instruments that might slip, the rumble of burs and stones. To this comes the mistrust as to how the appliances will look, and whether they will work?

Now even ordinary normal people will have a healthy fear of pain, but when it comes to the army of others who live in the sphere of the "Phenobarbital neurosis," the fear becomes vastly exaggerated. You might think that you could allay the fear by explaining the absolute painlessness that local anesthesia affords. But a person who suffers from a fear neurosis cannot be helped by logic reasonings.

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The problem, then, is to evaluate these "different heads" Hippocrates spoke about, and treat them according to their individual fears and apprehensions and distrust. For some people of slow, lethargic temperament, a good anesthetic is sufficient, but irritable, excitable people with highstrung nerves will stay nervous and apprehensive and will give no cooperation, even under local anesthesia, and these people need premedication.

In his introduction to Lundy's book on Clinical Anesthesia Wm. J. Mayo[2] said, when talking of Procaine for local anesthesia: "As an adjunct to this type of anesthetic agent there recently have appeared many substances or aids which have increased the efficiency of anesthesia, decreased the dangers, and added so greatly to the comfort of the patient as almost to revolutionize *surgical* anesthesia." And further on he says: "Dr. Lundy . . . has most carefully tried out the various anesthetic agents and their combinations and has relieved anesthesia not only of its terrors but its discomforts." Lundy[3] himself says: "Many a nervous patient can be made a good subject for local anesthesia by use of preliminary hypnotic agents in amounts sufficient to eliminate his nervousness." It seems to me that when the comfort of the patient has come to be important to men like Mayo and Lundy, it is time we also took account of it in our work. If we don't, we should be at the same stage as medicine was twenty-five years ago when the open ether mask was used.

When people come to the point where they have to go to the prosthodontist, they have a history of neglect of their teeth behind them, often because of their fear of going to the dentist. Decay has been allowed to run its course till all the teeth could be extracted under general anesthesia, and artificial dentures be made. We have, then, the completely edentulous patient who presents his specific problems both as to physiologic functions and emotional conditions. But as to the patient who has retained a few, or even most of his teeth, the job of bringing these remaining teeth to proper functional form sometimes necessitates reducing three or more surfaces of all the teeth by grinding, which is very trying to most patients. This procedure with our high speed diamond drills means hours of work in the chair, preceding the construction of the actual prosthetic appliances such as partial dentures, fixed bridgework, etc.

One attempt at alleviating the discomfort has been the Airdent in operative and restorative dentistry.

In the book on "Pain" by Wolff and Wolf[4] this statement is found: "The pain threshold sensation may be defined as the lowest perceptible intensity of pain." This threshold has been proved to be the same for all individuals and for the same individual at any time of the day under normal circumstances. But the reaction to, or the interpretation of, pain, varies tremendously according to the subject's temperament and neurotic tendencies. Under certain circumstances the pain threshold may vary. It will be lower, for instance, as a result of suffering of long duration or in case of inflammation in a local area; and it will be higher if narcotics are used, or during emotional upheavals. One pain may even obscure another. Shakespeare says in "King Lear": "But where the greater malady is fixed the lesser is scarce felt." The greater the fear is, the lower is the threshold of

the *reaction* to pain. Rare cases[5] have been found of remarkable insensibility to pain, and also cases where hypnotism, special faith, or personal determination has checked struggling or outcries, not by lessening the pain, but by suppressing the reactions to it. That the mind has power over fear and pain has been known for thousands of years. The Bible says: "Perfect love casteth out fear." So that, for instance, a mother may save her child from danger without noticing her own injuries. Plinius the younger tells about Arria, the wife of Paetus, whom the Roman emperor, Claudius, had condemned to death, that she saw her husband in doubt whether to take his own life or submit to Caesar's cruelty. Deeming suicide far better, she plunged a dagger into her own breast, then handed the weapon to her husband saying: "Paete, non dolet" ("It does not hurt").

What is needed to control pain, fear, and apprehension in dentistry is then: first, correct and complete local anesthesia, and second, proper premedication to alleviate and control the already sensitive nervous system, or else to prevent a normal person from developing a dental fear complex.

Some might ask: Are we not pampering these people? Do we have to premedicate? No! Not everyone. But if apprehension or fear is present we should not hesitate. Fear can be a very dangerous thing, and it seems more sensible to prevent its reactions than to treat them. Smith[6] tells about a patient who expected to faint after a Procaine injection, and who actually did faint after the injection though the solution used was not Procaine at all, but only Ringer's solution. This proves that the cause of his fainting was fear alone.

Fear, then, is to be taken into account. Another good reason for premedication is the unpleasantness which the operator experiences when working on a tense, unsteady patient, and still another reason is that the patient who has shown adject fear, especially if it is a man, will hate the operator, because of his subsequent embarrassment. As Goethe says in "Götz von Berlichingen": "Dass du ihn schwach gesehen hast, vergibt er nie!" ("He will never forgive you that you have seen him weak".) And that patient will not come back to you.

In surgery and medicine, premedication is not only used as central nervous depressant but also to control purely local physiologic functions. Similarly, we can to the greatest advantage use premedication to control the functions of the organs and structures of the oral cavity, and I am here referring to, for instance, excess salivation or excess function of the mucous glands in the mouth. These can be brought under control effectively and quickly. At the same time, the reflex action of swallowing which sometimes may interfere with accurate impression work can be stopped . The tension in the mouth can be relieved and the muscles of mastication relaxed so that a truer registration of jaw movements can be obtained. Some patients find it difficult to relax the tongue and facial muscles of expression while the work on their teeth progresses and keep grimacing. Here, too, a sedative can help; and gagging, however severe, can easily and quickly be brought under control.

Many articles on premedication in dentistry have appeared during the last couple of years, and the authors generally agree with Ruble[7] who comes to the con-

clusion that the ideal premedication has yet to be found: "The ideal drug should meet these qualifications: rapid onset, short duration, no side reactions." In these respects we might also say that the ideal *general* anesthetic has not been found either. But by combinations of drugs, and by variations in routes by which they are given, an ideal state of anesthesia can be reached, and the same holds good on premedication for clinical purposes, i.e., by selection and combinations of medicaments, the desired state of sedation and/or analgesia can be obtained. To quote Lundy[8]: "Since no single anesthetic agent or method can be used routinely with safety, special effort must be used to choose the best agent for use in each case." If the desired effect has not been obtained by the ordinary minimal dose of one agent, rather than administer a further amount bringing the original drug up to its maximal dose, a better and far safer sedation can be obtained by giving small amounts of other drugs to supplement.

Premedication is, of course, nothing new in dentistry. Alcohol[9] is the oldest sedative and hypnotic we know, and when only a light sedation is needed it is probably still the best we have. The effect is rapid, since absorption takes place in the stomach. However, because of its social implications, this drug presents difficulties for use.

For a number of years, the only drugs used in premedication have been those of the barbiturate group. But the use of barbiturates as we have been accustomed to handling them, given orally and in standard doses, is not very satisfactory. It takes too long before the effect appears because absorption does not take place until the drug reaches the small intestine, and up to four hours may elapse before complete absorption has taken place. The duration is too long, and if these drugs are given by mouth or hypodermically, we have no way of knowing what the result may be until forty-five minutes or one hour after administration, and, since the reaction and tolerance of the drug varies greatly, we may either get too much or too little depression. In some patients, the reaction may even be unexpectedly untoward, such as headache or even excitability, and we are not in a position to control these reactions.

By the *intravenous*[10] method we get an immediate index established of the patient's specific reactions and tolerance of the drug. And though some patients may be hypersensitive to the drug we use, we remain on the safe side since we administer it slowly enough so that the symptoms run ahead as possible warners against further instillations. Also, we are prepared to control the unusual reactions. For instance, not a few patients would be pleasantly sedated from barbiturates, whereas others may develop headache or become excited. Lundy[11] says: "It has been shown that a suitable combination of drugs is advantageous in that one drug neutralizes the untoward effect of another."

For premedication, medicines from three different groups of drugs are used:

1. *The narcotics:* Opiates and their synthetic substitutes, among which is meperidine (Demerol).
2. *The hypnotics:* Barbiturates, mostly pentobarbital sodium (Nembutal).
3. *The belladonna group:* Atropine sulfate and scopolamine.

Cullen[12] says: "In respect to the use of combinations of drugs it is emphasized that specific indications must be established for each drug in the combination and that a 'shotgun' type of therapy is not implied."

The basic drug among those used in our work for premedication is pentobarbital sodium (Nembutal) given *intravenously.*[13] A very important factor is that barbiturates counteract the toxicity of procaine.

If we have decided that the patient needs premedication, we give from 25 to 50 mg. of pentobarbital sodium intravenously, *very slowly,* at the same time keeping the patient engaged in conversation to watch the progress of sedation. Stop when the desired degree of sedation has been obtained. There is no standard average dose to go by, as the individual tolerance varies[14] tremendously. I have seen a young strong woman 22 years of age go into rather deep sedation on from 20 to 30 mg. of pentobarbital sodium, while another of the same age and weight took 250 mg. of pentobarbital sodium, and still an intravenous injection of 100 mg. of meperidine was necessary to make it possible to proceed with the work, though there was pulpal anesthesia.

One rule must always be kept in mind: Old people do not tolerate depressive drugs, such as barbiturates, very well. When the patient is over 60 years, metabolism slows down and he requires smaller doses. Administer the drug very slowly, and aspirate frequently to dilute the solution, or dilute with sterile water.

Contraindications against the use of barbiturates are liver and kidney diseases, and pulmonary diseases (asthma), because these drugs (the quick acting) are metabolized in the liver and (the slow acting) excreted through the kidneys[15]. But with such small doses as we use, this may be ignored.

It is well to realize that barbiturates are not analgesic but simply reduce anxiety. When under barbiturate sedation the patient is unconscious of the lapse of time and is thus free from impatience. The effect of these drugs when given in small amounts, such as from 25 to 50 mg., seems to stay evenly for about two hours, then wears off rapidly during another half hour.

When proper sedation and good local anesthesia have been obtained, but the patient still reacts on noxious stimuli with slight restlessness, faint escape movements, and a strained expression of the face, then, rather than give more pentobarbital sodium which might sedate the patient too deeply for cooperation, it is far better to give, *very slowly,* a small amount of meperidine (Demerol) intravenously; as a rule 25 mg. is enough, combined with 1/300 grain of scopolamine. The effect is incredible for such a small amount. The patient doesn't go into a deeper sedation but suddenly takes on a happier attitude to life in general and to the present moment of discomfort, and is completely satisfied and comfortable and more communicative. This goes to show the analgesic and euphoric effect of meperidine (Demerol). Sedation lasts about twice as long as if only pentobarbital sodium had been used.

Meperidine when given alone will produce some degree of nausea in 10 per cent of the patients, but if pentobarbital sodium is given in addition, it is my experience that it will afford counteraction. One patient out of every eight will experience some dizziness.[16] Both these drugs are respiratory depressants, and if given in large doses may cause respiratory paralysis, in which case artificial respiration and

oxygen must be used. However, this we can ignore, because such small doses as we use will not cause trouble.

Scopolamine or atropine sulfate may be added to these drugs if it is necessary to control salivation. Scopolamine is preferred by many anesthesiologists as the better of the two. In addition to being a very effective antisialogogue it also gives psychic sedation and has an amnesic effect. Even a relatively small dose of scopolamine in combination with meperidine (Demerol) may give the patient complete amnesia as to the possible discomfort he may have experienced in the dental chair. Scopolamine is also a respiratory stimulant, which should be of benefit if rather large doses of pentobarbital sodium or meperidine[17] are used. Both atropine sulfate and scopolamine may be dissolved in the solution of either meperidine or pentobarbital sodium. Atropine sulfate or scopolamine I often use alone to control secretion from salivary or mucous glands when taking impressions or cementing inlays and crowns. I give from 1/300 to 1/150 grain of either atropine sulfate or scopolamine, intravenously, very rarely more, and in a few minutes the patient's mouth is dry and stays so for a couple of hours.

There is one warning that should be kept in mind: Some people will come to your office already self-premedicated with barbiturates, and if this drug, for instance phenobarbital, has been taken one-half hour before the arrival at the office, the maximum effect may not appear until quite a while after the patient has received *your* premedication, and then, of course, the patient would go into undesirable deep sedation. But actually dangerous is the situation of the patient who has fortified himself against the ordeal with half a pint of whisky, because alcohol and the barbiturates are synergistic.[18] Some fifteen years ago a young woman 35 years of age who had received 3 or 4 grains of barbiturates at the office for an immediate reconstruction, was taken home by friends who gave her a couple of stiff highballs to cheer her up. Somewhat later they had to call in a physician to resuscitate her! An alcoholic is difficult to premedicate with barbiturates alone, but when meperidine (Demerol) and scopolamine are also administered a good effect can be obtained.

Some people have great difficulty accommodating to new facets of life, such as removable dentures, full or partial, may present. It is therefore advisable, during the last step, especially if anterior teeth are removed under local anesthesia and the appliances inserted, to keep the patient well sedated, because in this condition he is particularly susceptible to positive suggestion. Take advantage of this circumstance to assure him that his mouth will feel and look natural. If the patient is extremely nervous or hypercritical, use sedation under supervision for the first few days. During this time he will become accustomed to the new feeling and appearance and not be inclined to make comparisons.

When administering the narcotics or barbiturates, the question might come up if the patient might become an addict or a habitual user from this contact with the drugs. However, the authorities[19, 20] assure us that a few administrations with intervals of several days or a week will have no such consequences. But of course we must bear in mind that these are very potent drugs, and they should be used only when they are definitely indicated. Long appointments of two or three

hours should be arranged, and full advantage should be taken of the entire duration of the effect of the drug.

As to the technique of the intravenous injection, I can refer you to no better authority than Lundy.[21]

CONCLUSION

A practical method for premedication in dentistry has been presented, by the use of pentobarbital sodium, meperidine, and scopolamine or atropine sulfate, given intravenously in small doses, either singly or in combinations as indicated. By using this procedure in combination with local anesthesia, it is possible to control the patient's emotional instabilities and conduct extensive operations without hardship either to the patient or operator.

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NUTRITION THERAPY BY DENTISTS.

DANGERS, ADVANTAGES, TECHNIQUE

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INTRODUCTION

ABOUT SIX YEARS ago, two very active officers of the American Academy of Applied Nutrition cornered the editor of the Journal of the Southern California State Dental Association, bought him a drink, and made an irresistable proposition. They offered him the chance to found and to edit a Journal of Applied Nutrition with a free hand.

It was not the free cocktails, but the free hand; not the bouquet of bourbon, but the scent of printer's ink; not the warmth of alcohol, but the kindled fire of a crusade that caused him to accept this new challenge, this chance to do something worthwhile on the broad battlefront of man against disease. How often have we all felt frustration at the pitifully meager output of our own two hands in the limited hours of our professional careers? Here was an opportunity to attack disease at, or even before, its inception, to attack what, from a health standpoint, is original sin!

This is the story of my "seduction." Almost overnight I found myself labeled a "nutritionist" and expected to display encyclopedic familiarity with a subject so vast that (I believe) less than 10 percent of it is yet understood by mortal man. The new Journal we designed was not bad. It had a cover design that will be as expressive of truth in a thousand years from now as it was in 1947. Devoted to many problems of building a finer, stronger, and wiser American people from the soil, rain, and sun of this, our land, the Journal of the American Academy of Applied Nutrition is the voice of a small but growing nucleus of physicians, dentists, and nutritionists. Working together they hope to focus more light on the relation of man to his food. If you are one of those who would rather create health than rescue patients from disaster, the Journal and the Academy may be of help to you. (This is impersonal advice, I am no longer its editor.)

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DANGERS

I. There are definite dangers involved when the dentist begins the study and practice of nutrition therapy. The old saying that "a little knowledge is a dangerous thing" applies particularly to nutrition. It is the novice who has positive beliefs on every angle of food chemistry, the neophyte who knows every answer. With few exceptions, the fanatic is the least informed member of any group, and fanaticism is as prevalent in nutrition as in religion.

To me, nutrition and religion have something in common: *God.*

It is impossible to know life (as we, who study and observe daily the anatomic, physiologic and psychologic details of living creatures, learn to know it) without accepting the existence and omniscience of a Supreme Architect, the Omnipotent Creative Doctor, in whose footsteps we, His repairmen, follow. To believe that such an intellect would create or develop mechanisms, such as plants and animals, including man, without providing utterly adequate fuel is slightly ridiculous. Our scientists have uncovered evidence indicating that our ancestors walked on this earth a million years ago and may have roamed it in a less erect posture for countless ages before that. Had those early men not had an adequate supply of every essential nutrient, they could not have survived the perils and the hardships of those primitive times. Probably the first million years, like the first million dollars, were the hardest. And had those ancestors not survived, you and I would not be here.

How did they do it? No vitamin pills, no "enriched" bread, no "quick-energy" in cellophane wrappers or corrugated bottles! Just lucky, I guess.

II. The second great danger comes from knowing a lot about a little. It is too easy to concentrate upon the leaf, forgetting that if the tree dies, the leaf is no longer important. It is the chief hazard of the specialist, and every dentist is a specialist in the field of health. Each chemical entity which enters the body through the alimentary canal, whether we label it a food, a drink, a condiment, a confection, or take it as a food supplement, a medicament, a euphoric, or by error or ignorance, has to be considered in its relation to the whole organism. A poison which causes death by paralyzing the heart muscle, kills not only the heart but the creature. There is as of April, 1953, no known food, or food essence, which can be swallowed, that affects one body structure or function alone without in some way and to some degree affecting other structures and functions.

This has made vitally necessary the concept of total health. When we rivet our attention upon that goal, the parts of a very confusing puzzle drop easily into the master plan. We learn that the food intake that seems best for dental health seems also to satisfy the needs of all other body tissues. We discover that the ability of the organism to digest, assimilate, and utilize nutrients is itself dependent upon the quality of the supplied nutrients. There can be no diet for dental health that is not equally a diet for total health. We find no "energy" food that does not provide, or replace or displace, certain nutrients.

III. The third danger lies in our limited training in general physiology, our outdated college fundamentals, our lack of participation in nutrition research and postgraduate study. These can all be overcome without undue effort.

IV. The fourth danger comes from our limited knowledge of the exact health status and alimentary capacity of each particular patient. While we may see certain universal principles governing nutrition, we must also recognize and provide for the individual variations in food intake made necessary by the health of the particular patient, by concurrent medical care, by religious, racial, cultural, and esthetic food habits. It is useless to prescribe foods, the very thought of which nauseates. It is equally pointless to recommend foods which violate the taboos, or would subject the patient to ridicule. The conscientious doctor even considers the family pocketbook, and recommends to the low income group foods which provide the essential nutrients at a reasonable cost.

V. The fifth danger is that of eliminating tooth-destroying items in the diet without replacing them with more acceptable items. When we condemn the mouth-fermentable, high-calorie, low-nutrient, refined carbohydrates in the diet of a child, and then provide no other source of the tremendous number of calories an active youngster needs, we are forgetting the principle of total health. This danger can be offset, like the others, by study, and by careful diet analysis and prescription.

VI. The final danger is that we will adversely affect medical-dental relations. This has been done. I do not believe it is entirely avoidable. The average medical man knows little more about nutrition than the average dentist. He knows a lot of diets, but they are all specific diets, to gain weight or to lose it, to keep a diabetic patient balanced between insulin and coma, to minimize the superficial symptoms of allergies and asthma, and so forth. They are not diets by which total health can be achieved or maintained. His whole schooling and experience has been with the problems of the diseased; he is virtually unacquainted with health. People come to him after they have lost it, and leave him just before they completely regain it.

The practicing physician has let the field of nutrition go by default. Today the public turns to the pharmacist, the health-food-store clerk, the naturopath, the chiropractor, osteopath and, yes, the dentist, to learn what they should hear from the only man licensed to treat whole bodies. I do not believe dentists should diagnose and prescribe for dietary faults, but until a larger percentage of medical men accept this responsibilty, we dentists will do our best.

ADVANTAGES

1. Dentists have been very sensitive to statements that they are primarily repair men because so much of their time is devoted to the replacement of missing parts, either of teeth or of mouths. The dentist who terminates his service after merely restoring that which has been destroyed, without teaching the patient the way of preventing further trouble (whether or not the patient follows the prescription), is guilty of being a dental repair man. He is actually not much more than a highly trained and licensed technician. The dentist who educates his patients, as well as he is able, to prevent in the future the disasters of the past, is a physician of the highest order. The medical man who is content to restore the ill or damaged individual to momentary health without at the same time trying to correct the life situation so that the patient will enjoy continuing good health, and who assumes that the patient who does not demonstrate active disease is therefore a well person, is a medical repair man, a licensed medical technician. If, however, within the limits of his knowledge

and ability, he strives at every opportunity to perfect the health of his patients, and the group health of his community, he is then a healer of the highest order.

II. The conservation of the patient's dental health is not the only benefit from nutrition therapy. Our restorations, no longer immersed in a broth of fermenting carbohydrates, last much longer. Abutment teeth do not disintegrate beneath denture clasps. Periodontal structures respond more permanently to gingival therapy. We spend less time replacing our failures, or trying to explain them away. Our reputations do not suffer.

III. The time thus saved permits us to accept new patients, widening our sphere of service, our worth to the world.

IV. Children who grow up in our practices with trouble-free mouths because of our coaching may never (personally) contribute much to our incomes, but they fatten our egos; they are our hostages to eternity.

V. The tactful dentist can build medical friendships and respect if he avoids fads and fanaticism, keeps fully informed, and respectfully consults the family physician.

TECHNIQUE

Of what are we made?

If we omit the water content of the body, a person of average build is almost entirely protein. Only 4 per cent of the body weight consist of inorganic minerals, chiefly calcium. The principle carbohydrate is glycogen with about 8 ounces of it stored in liver and muscles. Fats are a variable item, but can be less than 1 per cent of body weight with no evidence of diminished health.

The body can build fat from carbohydrates or proteins. It can build carbohydrates from fats or proteins. It cannot build protein from fats or carbohydrates. It can build protein only from the protein fragments, the amino acids.

Blood cells are chiefly protein, and plasma is a protein suspension.

Among the activators, almost all enzymes are protein and the vitamins thiamine, riboflavin, niacin, and para-aminobenzoic acid are the better known proteins. The hormones insulin, epinephrine, thyroxin, and the pituitary secretions all have the characteristic NH_4 radical.

We are not only built by proteins, we are operated by them. Charles Glenn King,[1] Director of the Nutrition Foundation, writes, "—new discoveries show how quickly the body functions are distorted from their normal activity when good quality proteins are omitted from the diet. The disturbances are evident within one day, and severe within a few days."

Quality in a protein food is determined by its content of all the essential amino acids. Meats, eggs, milk, and natural cheese are the principal sources. No vegetable, even soy beans, can compare in quality.

The body utilizes food in two principal ways: as fuel to produce heat and energy, and as a nutrient to build, to recondition, and to replace tissues. Calories have no known nutrient value. They represent the heat and energy potential of the food. The caloric needs of individuals according to their age, sex, activity, climate, etc., are rather well established. During the last century the reduced physical activity of our people, working only half as many hours a week as their grandparents,

traveling in an auto instead of on foot, and working with their fingers instead of their biceps, has cut their caloric needs in half. The Hollywood obsession has made the immature and undernourished female the model that other women count calories in order to imitate. Unquestionably we need less fuel than our more active ancestors, but can we be certain that we need less nutrients than those ancestors?

Walsh[2] claims that the exigencies, tempo, and strain of high-speed modern life have actually increased our need for the essential nutrients, particularly the vitamins, amino acids, and trace minerals.

The phenomena of hunger have been explored by some investigators, but the literature contains very little about the facts that produce satiety. McLester[3] considers that the foods most satisfying are those that remain longest in the stomach and intestine and call forth the greatest secretion of digestive juices. He then contradicts himself by quoting Kestner[4] on the high satiety value of sugar used as a dessert at the end of a meal. Sugar, which has little bulk, requires no hydrochloric acid in the stomach phase, and no compensating alkalinization in the intestine. It satisfies no single requirement for a food giving between meal contentment. What it does is to quench appetite. You can buy pills that do it, you can smoke and do it, and you can take sugar and do it. In other words, it brings a short-lived but immediate satiety. A contentment with starvation! Thus the sweet dessert at the end of a meal makes one feel well fed without being well fed. Many obesity cures are on the market today that make use of this peculiar property of high caloric, non-nutritious, foods. The patient merely takes candy or an equivalent appetite quencher shortly before mealtime. It is possible that appetite is directly related to caloric needs rather than nutrient needs and is controlled by a secret calorimeter somewhere within us.

Whether the food capacity be limited by the size of the stomach, by a caloric meter, or by such psychologic factors as habit, the five senses, and the emotions of the moment, we can be sure that the reduced intake imperils our supply of the vital nutrients.

With modern emphasis on a reduced and controlled caloric intake and with the need for the essential nutrients at least as high as it was when caloric intake was twice as large, it seems obvious that foods must be selected which will supply the largest amount of nutriment for the smallest cost in calories. Algebraically this can be expressed by showing the nutritive value divided by the caloric value. Tell your patients to "count the calories your nutrients cost you!"

Economically speaking, buy foods which give the most nutriment per dollar; physiologically speaking, select the foods that provide the most nutriment per calorie. And remember the warmer the climate the fewer the calories needed! To make a hot day hotter drink a cold bottle of "canned heat", be your own "coke" oven.

These facts automatically banish sugar in any form, refined or raw, except where it is an inconsequential part of a nutritious food. They banish those flavored simple-syrups with their tooth-dissolving phosphoric acid content that are today a far greater danger to the health of our youth than marijuana and alcohol, since they seem so innocent and have social acceptance. It banishes the demineralized,

devitaminized, devitalized, bleached white flour products. The so-called "enrichment" program, a sop thrown to an awakening public, restores but a small fragment of the value stolen from the whole grain so that it can be sold back to you at a higher profit as wheat-germ, and as vitamin supplements.

By this banishment of sugar and refined flour products, we can take from the diet those food factors which cause almost all dental disease. All caries that eats its way through enamel is the result of carbohydrate fermentation. There is considerable evidence accumulating that the most frequent systemic factor predisposing to periodontal disease and alveolar ridge resorption is disturbed calcium-phosphorus balance for which the low-nutrient, high-caloric foods, and the excess phosphates may be blamed.[5] We could banish almost all dental disease, if, if only pepole would follow our recommendations.

DIAGNOSIS

The evaluation of our patient's nutritional status starts with our first examination. In order to capture his attention and prepare him for later training, ask, "Know who ate the holes in your teeth? . . .You did!" When a little later he protests that he doesn't eat much candy or bread, and swills only an occasional coke, dramatize the problem by saying, "Let's pretend that you and I are detectives. The cavities or wounds in your teeth are evidence that a crime has been committed. Science has proved that the weapon is an acid produced by fermenting sugars and starches. The mystery is how they got into your mouth. Now, you work out that problem before our next appointment." "You find out what is guilty!"

In selected cases we have the patient keep a true record of everything swallowed (foods, drink, supplements, medicines) for seven consecutive days. This is then converted into terms of nutrients, totalled and compared with what we (in 1953) believe to be a satisfactory diet for a patient of that sex, age, physical type, and degree of activity. We use the Walsh method of evaluation.

PRESCRIPTION

Since we are prescribing diet solely in our capacity as dentists, our first concern must be to eliminate the cariogenic factors, the mouth-fermentable carbohydrates. We must then restore the balance in the diet so that an optimum amount of the essential nutrients are assured, and the caloric content is proper.

We must be certain that all of the vitamins are included in optimum, not minimum amounts, and in compatible combinations. We must include not only the vitamins already discovered but those that are still undiscovered. And then we must have the prescription filled by a pharmacist who is qualified.

Dont's laugh! You and I know there is no pharmacist, no doctor, no scientist on earth who could compound such a vitamin pill. Man has been able to tear foods apart but he has yet to learn how to reassemble them; like a child with Daddy's watch, like the King's men and Humpty Dumpty.

But there is one Pharmacist who still measures up. His products are available to every doctor and patient in the world, including Russia. His name is *God*.

When it comes to nutrition, I am a fundamentalist, a revivalist. We can never go back to primitive diets, nor should we. Food processing necessary to its storage,

transportation, and distribution over vast distances and considerable periods of time are vital to our way of life. It is equally vital that we understand what those processings destroy in the foods; that we induce (by economic boycott if necessary) the food processors to conserve every last possible nutrient property; that we offset in our diet and that of our patients those losses by emphasis on undamaged foods provided by nature.

Milk, which can be described as a high-mineral, high-protein, high-vitamin, low calorie growth tonic, is compounded by God in little laboratories that are justly famous; a complete food for the young of each species.

In liver, in Brewer's yeast and in wheat germ, we find vitamin formulas that are poetic in their completeness. No synthetic tablets equal them.

The egg is a perfect example of God's technical ability. Here within a neat capsule the two cells that became one in a moment of ecstasy set up housekeeping. Every protein, every fat, every carbohydrate, vitamin, mineral, drop of water, and secret ingredient that they will need for twenty-six days is stored within that shell, in just the right amount and in perfect condition. And there isn't anything wasted. Have you noticed that there is no outside plumbing on an egg shell? Everything is there to give that chick the strength to burst forth as healthy and as self-reliant as a Republican or a Southern Democrat, asking no odds, expecting no paternalism, wearing no mink!

Learn to prescribe for yourself, and for others, the foods that are packaged by God!

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THE PHYSIOLOGIC ASPECTS OF PARTIAL DENTURE RESTORATIONS

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THE PURPOSE of this article is to emphasize the need of a more effective diagnosis before rendering partial denture prosthetic service.

The morphology of the parts involved are quite clear in the dentist's mind, but, unfortunately, he too often jumps from this concept directly to the mechanical considerations. As these mechanical techniques are well known, we shall confine our concern to the problem as to when their application works in harmony or interferes with the physiologic norm of the teeth and adjacent tissues.

In view of the foregoing statement, we would do well to present an objective and constantly keep it in mind. DeVan[1] does this for us in an excellent manner. "Our objective should be the perpetual preservation of what remains, rather than the meticulous restoration of what is missing."

To attain this ideal, a thorough and adequate diagnosis is essential. To understand what we mean by "thorough and adequate," let us divide the problem into parts and discuss each in detail.

1. The past and present general health and oral health history of the patient.
2. The remaining teeth.
3. The design and functional movement of the proposed restoration.
4. The normal environment of the completed restoration.

THE HEALTH OF THE PATIENT

A consideration of the general health history convinces the patient that the dentist is sincerely interested in him or her as a personality, and that the dentist is not merely a salesman of dental merchandise whose objective is to place some sort of contraption in the mouth so teeth will fill spaces and chew food. A personal interest in the welfare of the patient as a whole is a new experience, and a realization is developed that the health of the mouth cannot be separated from the health of the body.

The concept is suggested that the success of dental restorations, particularly from the standpoint of the length of time they are retained, is closely related to body

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health. It is a viewpoint very few patients have appreciated. The more dramatically it is demonstrated to patients that the mechanical production of a dental restoration is merely part of the procedure in maintaining or restoring an optimum health level, the sooner the dentist will occupy a place in the patients' esteem as an essential segment of their health program.

However, it behooves the dentist to interest and qualify himself to interpret the unfavorable influence certain previous episodes may have had upon the present and future oral condition. Maybe the patient is anemic, has low blood pressure, or has spongy red gum tissue, or is on the verge of a nervous breakdown. These are just a few outstanding items that physical diagnosis reveals. In the last few years it is most gratifying that more books are now available for the dentist's library on Hygiene, Diagnosis, Nutrition, etc.

The mucous membrane and tissues of the mouth exhibit diagnostic signs more apparent than any other part of the body. The signs may not be easily translated, but they at least warn the dentist that something is wrong. If beautiful restorations are placed in unhealthy mouths, then anything can happen. No two patients will react the same, any more than any two restorations are alike. Consequently, an interpretation of the patient's past and present general health into terms of a dental prognosis is essential to a better understanding in the matter of patient-dentist relationship. Most of these people are in the category of subnormal health. They don't know they are sick, or at least do not demand medical attention. The dentist is fortunate when he can secure medical assistance for a patient who he knows is in a state of poor health, but does not exhibit alarming medical symptoms. A great many patients are not interested in improving their slowly degenerating bodies until they are dealt a serious blow. They are imbued with the fallacy that a miracle drug will quickly save them. In the meantime, prosthetic restorations are quickly blamed as unsatisfactory because they have been asked to function with the severe handicap of a patient in ill health. How often have you wished you had never met certain patients?

The extra time you spend on investigating the physiologic aspects the patient presents in their relation to the functions of the proposed restoration is very small as compared to the time you might waste at a later date to satisfy an unhappy individual. We appreciate that some people in a substandard health condition very frequently adjust themselves to anything, but to proceed on this theory is a gamble as well as bad practice.

It would be hard to imagine that any dentist would fail to use a complete roentgenographic examination. We are interested in the integrity of all restorations which have been placed in the remaining teeth. We must know the condition of the pulp resulting from these operations as well as from existing caries. What is the size, shape, and placement of the tooth roots as well as the tissues surrounding them? Are they strong or weak? Is the periodontal condition good? Is the bony structure under the proposed saddle area dense, or is the cancellous structure poor and lamella thin and unfavorable? If so, the cause might be ascertained and a remedy suggested. Perhaps you or the physician will not successfully ascertain the cause, but at least the patient will be benefited in some other unexpected manner.

Your physiologic approach and treatment for an unfavorable condition produces an awareness on the part of the patient that a handicap exists, and difficulties ensuing are not so quickly blamed upon the dentist.

Our diagnosis could not be completed properly without the help of study casts. With this help, traumatic occlusion can be coordinated to observations of abnormal evidences in the roentgenograms, and the physiologic status of the tissues around the remaining teeth. We must not be too quick in deciding that we are looking at a patient in poor general health, when our visual evidence in looking at the soft tissues is due to trauma or mechanical irritations.

The two casts, when properly mounted, will demonstrate the existing vertical relationship, and point out how much further study is needed to determine what the vertical relationship should be. In this connection, the work of Boos[2] and Jankelson[3] merits very close study. From the standpoint of physiologic comfort, and from several different aspects, they demonstrate the need of free-way space. It should average three millimeters in the anterior region and about one and one-half millimeters in the posterior region. Their work indicates the importance of making certain that free-way space exists between the patient's natural teeth; also that the partial or complete denture be constructed so the patient has this space between his teeth when the mandible is relaxed and is in a state of physiologic rest.

This brings to an end our blind attempts to open the vertical dimension which has sometimes been done beyond the rest position, or the opposite situation resulting in too quick occlusion or no free-way space at all. The physiologic approach teaches us that we were mistaken in the idea that we could stretch a muscle, and after a period of time it would hold that position and relax.

It seems that the muscle fibers have a preordained length. The state of physiologic rest demands that they be not held stretched nor contracted. They will function as desired, but if they are not permitted to return to their predestined rest position, a constant battle ensues.

The determination of this factor is exceedingly important, and its neglect perhaps explains many of our puzzling difficulties in past years. The method of its attainment are outside of the scope of this paper, but as a physiologic factor in denture construction, it may often spell the difference between success and failure.

THE REMAINING TEETH

The decision as to the removal of any of the remaining natural teeth must now be made. The position of a tooth, size or shape of the root, clinical condition, roentgenographic diagnosis, and value to the patient all enter into the diagnosis. The study cast is again a great aid in doing this. The cast has previously been mounted on the movable base of a dental surveyor. We are now ready to design the metallic structure of the partial denture restoration.

With oral health in mind, we propose to produce a restoration which permits functional movements to take place without transmitting an undesirable strain from these movements into the involved teeth. The functional movement of a partial denture must not be resisted. It should be controlled or limited. When tissues are

traumatized beyond physiologic tolerances, the degree of damage resulting is proportionate to the force involved and to the prevailing physiologic health of the tissues.

THE DESIGN AND FUNCTIONAL MOVEMENT

With aid of the surveyor instrument, the line of insertion is chosen. It is usually always a compromise between the ideal for each abutment tooth. In order to secure sufficient retention on one tooth, the ideal amount must be given up on another. Occasionally esthetics is a controlling factor. The tipping of one tooth may alter the ordinary choice of the path of insertion. When the choice is made, the base of the cast is securely locked, and we proceed to mark the survey line on all the involved teeth as well as bulges on the gum that may produce an undercut. Let us call the space below the survey line the infra-bulge, and the space above it the supra-bulge. We are now ready to design and locate the various parts of the framework of the restoration. We will enumerate the parts involved as follows: (1) the connector bar, (2) the occlusal rest arm, (3) the occlusal rest, (4) the retentive arm, (5) the reciprocal arm, (6) the indirect retention arm, and (7) the framework.

The Connector Bar.—In a mandibular restoration, the connector bar connects the right and left sections of the framework. It is made as heavy as possible to resist bending and twisting strains. The heavier portion is placed nearest the floor of the mouth, and with the taper in its width becoming thinner under the gum festoon. The tissue contact side need not be relieved as the function of the indirect retention arm is to prevent the edge of the connector bar from being vibrated into the gum tissue. A maxillary restoration has never less than two connecting bars. Do not use one bar of horseshoe type, or place one large bar across the center of the palate. Neither of these type of bars are sufficiently rigid or strong. Maximum rigidity is a fundamental principle of all connector bars. The posterior bar is placed across the same location as if it were the posterior section of a complete denture. In this location it does not bother the patient. The anterior connector is preferably threaded between the rugae, and across the anterior end of the vault. In this area and buried beween the rugae it will not annoy the tip of the tongue. Two small bars joined in the center are better than one heavy bar which would bother the tongue.

The Occlusal Rest Arm.—This arm arises from the saddle opposite the proximal surface of the tooth. It should never be caught in the surveyed undercut, and the space between it and the tooth should be the same as exhibited by the surveyor rod. It should be wide enough to be strong and heavy, as it and its rest must withstand more abuse than any other part of the restoration.

The Occlusal Rest.—This is the right angle terminal of the rest arm. Enough space should be planned so the occlusion will permit a rest heavy enough to carry the load and not break off easily. This is the most frequent type of breakage. The tooth preparation under the rest is most important. In the majority of cases, a metal restoration in the abutment tooth will be the seat. This is more favorable as it permits the operator to produce an ideal seat for the rest. Imagine a miniature teaspoon imprinted into the metal. It is the ideal shape because it permits rotation

or slippage buccolingually or mesiodistally. Any rotation or slippage in this rest can take place without transmitting an undesirable force into the abutment. The occlusal rest should extend away from its arm at an angle as close to 90 degrees as possible. A slight angle more acute tends to hold the restoration favorably in position. Do not place an occlusal rest so it will act as an inclined plane. This is exemplified frequently by the use of the lingual surface of a cuspid as a rest seat. In function, the traumatic pressure from the incline plane will loosen the tooth, or the retentive arm, generally both. The lingual surface of a cuspid should be reformed with an inlay or crown, and a proper stress absorbing seat prepared for the occlusal rest.

The Retentive Arm.—This arm usually rises from the bucco-proximal area of the saddle and terminates upon the tooth in the infra-bulge region. Its terminal end may be the normal size of a cast arm, or it may be developed into a 90 degree C-shaped end, depending upon the degree of undercut exhibited in the infra-bulge area on that portion of the tooth. It is most important to realize that when the restoration is placed in the mouth in a normal rest position, there is absolutely no strain or pressure between the terminal end of this arm and the tooth. The metal hardly touches the tooth at all. Under no condition bend this arm to bring about pressure upon the tooth. The only time this arm is under strain is when it is forced over the bulge in removal or insertion of the partial denture. At this point, it would be a good time to demonstrate the purpose of this type of design.

With biologic perspicacity, let us mentally visualize the chain of events when oral function causes an extension saddle to move. On the occlusal level, picture the occlusal rest as a loosely hinged end of a movable lever. By means of the occlusal rest arm, the lever is dropped to the tissue or saddle level, thereby changing somewhat the normal graph or arc of said movable lever. Now from the saddle base, which, although it is close to the tooth and moves in a greater arc resulting from the length of the occlusal rest arm, arises the retentive arm. The length of this arm increases the movement of its terminal end which moves away from the tooth and its undercut area. Consequently, because the retentive arm does not clasp or bind the tooth with a death grip, it does not throw a traumatic pressure upon the periodontal membrane every time occlusal pressure moves the extension saddle into the displacable tissues. If the terminal end of the retentive arm were placed on the mesio-buccal aspect, our objective would be defeated, as the movement would press against the tooth instead of away from it.

The use of designs wherein the occlusal rests and retentive clasps resist functional movement is purely a mechanical concept. Progress in dentistry demands the recognition of biologic engineering as the only acceptable approach when interference with living tissues is expedient.

The Reciprocal Arm.—This arm rises from the connector bar opposite the retentive arm which usually places it in the mesiolingual aspect. The survey placement keeps it out of any undercut so its terminal end has no retention. It touches the tooth on the survey line, and the terminal end rests on the supra-bulge of the tooth. Its function is to resist lateral displacement of the saddle on the opposite

side of the mouth. Many assume that its purpose is to reciprocate the force applied by the retentive arm, but the retentive arm is only under strain when an effort is made to dislodge or insert the restoration. It is chiefly a stabilizer against bucco-lingual movement of the saddle. Now the importance of a rigid connector bar can be realized. In our previous conception of saddle movement into the tissues and the resultant movement of the arms it is to be noted that the reciprocal arm is more distant from the axial center of movement than the retentive arm. Because of this, its terminal end tends to be lifted from its seat when the saddle is depressed, and not being caught in the infra-bulge, the tendency is to lift and move upon the supra-bulge. Consequently, no traumatic force is directed into the tooth which would occur if this arm were terminated as a retentive arm in the infra-bulge area.

Many times the first premolar is the abutment tooth with a distal extension saddle. In such cases, the reciprocal arm must also function as a device for indirect retention. To accomplish this objective, a 90 degree extension is included on the terminal end of the arm, and it is directed over the marginal ridge of the tooth into the mesial pit. The possibility of this accomplishment must be determined in the initial survey, and preparations must be made in advance so it can be done.

Indirect Retention.—Again visualizing the teeter-totter movement in function of the partial denture with the occlusal rest as the fulcrum point, we observe that the maximum permissible pressure upon the saddle brings framework movement to an end. However, in connection with movement in the opposite direction, we have the lifting action of sticky food, and in maxillary restorations the force of gravity. While this is not comparable to muscular forces, it is sufficient to produce trouble and should be controlled. The laws of leverage indicate that the more distant from the fulcrum point the movement of the lever be stopped, the more easily it can be accomplished. Consequently, for a molar or premolar abutment, the mesial pit of the first premolar is used. The arm is the same as the reciprocal arm except that its terminal end has a 90 degree extension to seat into the mesial pit. Failure to use this device is usually the cause of soreness under the lingual bar of mandibular dentures. In a restoration wherein the natural remaining teeth are cuspid to cuspid, a complete secondary connector bar is used across the lingual surfaces of the lateral and central incisors. The cuspids are reformed with three-quarter cast crowns, turning them into first premolars. This gives us a proper occlusal rest and a mesial pit from which the secondary bar arises to thread its way across the lingual surfaces to join with its counterpart from the opposite side. The lingual surfaces of the central incisors are the most distant points from the fulcrum line. Do not use arms with arrowhead terminals between the teeth for this purpose, as you will move the teeth and only partially succeed in your objective.

The Framework.—Be sure that no portion of the framework, including the base of the retentive arm, is caught in an undercut of the gum tissue. The framework of the saddle is usually raised above the tissues to give stronger and better adaptation for a plastic base material. To prevent casting metal arms unto an undercut, such areas are blocked out on the master cast before it is duplicated. Sometimes the retentive arm is very short, and consequently would lack resiliency.

This objection may be overcome by creating a hairpin type extension away from the saddle and on the return end start the base of the retentive arm. A crack can be created between the side members of the hairpin design by inserting a thin piece of mica through the wax pattern into the refractory cast. When polished, it appears to be a solid piece of metal with a crack as a defect. Use stainless steel instead of mica if the casting is made of chrome metal.

Let us realize the importance of visualizing the movements of an extension saddle. Consider the shape of the base, either flat or well rounded. The effect of lateral trauma as produced by cusp impedance, or lack of free-way space causing the patient to grind his teeth together constantly. Add to this the rigid attachment of a typical clasp to the abutment tooth, and you have the picture of contrast between the mechanical concept and the biologic concept which holds an appreciation of the physiologic requirements of the patient.

THE NORMAL ENVIRONMENT OF THE COMPLETED RESTORATION

It is outside the scope of this paper to attempt a comprehensive discussion of the normal environment of the completed restoration. Let us simply recognize the possibilities and attempt to do something about it. The determination of this status was previously mentioned as part of our diagnosis.

Let us assume that the opinion rendered was that the oral tissues were in poor condition due to systemic causes, and also that the patient was interested and willing to change accustomed life patterns and habits in the interests of better health. Without complete and enthusiastic cooperation from the patient, the time spent on the subject is often wasted. Unfortunately, many people must become sick enough or old enough, before they are interested in better nutrition. Change of dietary habits requires self-discipline which is not a popular philosophy. Basically, almost everyone is deficient in the essential minerals which have been removed year after year from the soils upon which most of our food is grown. Albrecht[4] and Yerkes[5] have often demonstrated this fact. Four years ago Laing presented a marvelous essay[6] on systemic disturbances as they are reflected in the mouth. Laing demonstrated how neurologic dystrophies result from a lack of essential minerals necessary to produce the proper enzyme action required to repair and rebuild the myelin sheath. Yet we dentists place dentures upon a nerve system full of electrical leakages and sometimes short circuits. We naively call the patient neurotic and try to escape our dilemma as quickly as possible. We take better care of the ignition system of our automobiles.

One of the best expositions of the importance of trace mineral nutrition is by Chester.[7] He quotes Cavanaugh of Cornell: "There is one major disease, and this is malnutrition. All other diseases to which man is heir are results of this one major disease."

In further support of the general lack of trace mineral elements in our food and soil, the work of Gilbert,[8] and Cook and Millar[9] demonstrates how visual symptoms in plant life can be diagnosed and definite treatment initiated.

The outstanding deficiency symptoms in plant life are more easily interpreted than is the subnormal oral syndrome. The story of cobalt in Wisconsin and copper in Florida is well known. The new cobalt vitamin B^{12}, and zinc in insulin, is also known to most of us.

Sumner and Somers[10] tell us that a liver cell could contain a thousand different enzymes, and Kleiner[11] states that many of these enzymes contain the metallic ion. These enzymes are colloidal catalysts of absolute specificity, each with its individual normal velocity. Consequently, we can safely conclude that if the blood stream fails to carry to the tissue cells the traces of essential minerals they biologically require, then their metabolic function will be reduced from the norm in proportion to the degree of starvation.

Martin,[12] in his discussion of "Kinetics of Enzyme Action," seems to sustain the above opinion by the following statement: "First order reactions are those in which the rate of decomposition is directly proportional to concentration."

Now, let us bring ourselves down to a simple consideration as to what we are to do about it. Regardless of the complexities of all these biologic reactions, let us resolve to study nature's plan of life, and how close we can induce our patients to adapt themselves to it, if they are to enjoy health which is synonymous with oral health.

We are not concerned about any specific mineral deficiency as a blanket coverage is essential. As very few persons can secure food grown on organic mineralized soil, a supplement to our daily intake is the general policy. We know that plants growing in sea water of the ocean have the highest mineral content of anything we can buy combined in the organic form. Four five-grain Sea Kelp tablets per day is a nominal dose regardless of the excessive amounts advocated by enthusiatic manufacturers. Certain organic extracts from alfalfa grown on highly mineralized soil are also very effective. Some advocate pure inorganic replacements. Undoubtedly, in many cases, good results are secured. The field is so vast and the workers so few, let us not quibble over details wherein proof is not easily available.

Much of our time has been spent on essential mineral deficiencies, not because it is the only basic cause of poor oral health, but chiefly because it is so seldom mentioned. The problem of vitamin deficiencies is extremely important. It should be diagnosed, and suitable steps taken to remedy the condition and remove its cause. Since dentists love complicated techniques, why not accept the challenge of oral health and match your skill with such a worth-while cause?

So-called modern living has introduced a galaxy of problems which results in shortened living. Another wolf dressed in sheep's clothing and most strongly allied with habit, misinformation, weakened will power, is the excessive use of sugar straight from the sugar bowl, and the many attractive combinations devised to increase its use, and lure the unsuspecting into the false security of exogenous energy production. The greater the fatigue, the more sugar demanded. Permit me to mention dental caries as a simple systemic expression of a disorganized, imbalanced metabolism. If the teeth degenerate faster than soft tissues inside and outside the body, must teeth be the only point of interest we have in our patients?

With meticulous care we secure accurate impressions and balanced occlusion. Of what avail is all of this if we have no concern about the physiologic environment and the future integrity of saddle bases? The consumption of excessive carbohydrates has a terrific impact upon our normal biologic life. Even with all reasonable effort to avoid sugar, a goodly amount will still be consumed. The elimination of this modern habit is the most fruitful step toward good health that anyone can undertake.

Since I cannot at this time discuss all the reasons that may be needed to convince you of these facts, at least let me offer the work of Abrahamson and Pezet[13], who bring to public attention the outstanding work of great medical men in helping to diagnose the widespread but obscure disease of hyperinsulinism. If this is not sufficient evidence, then study the work of Sandler[14] and see the relationship of sugar and polio. If catastrophic citations are needed to help change life patterns, then their use is warranted.

One more phase of this mouth health improvement program is also important for our consideration. The biologic effect of the intake of chemicals in food products is an extremely serious situation. The revelations brought to light during the hearings of the Select Committee in Congress[15] is the most educational and fantastic reading material one could desire.

The poison sprays found on our vegetables and fruits; the unknown effects of chemicals placed in our bread, canned goods, and other food and drink causes one to speculate whether the overcrowded mental hospitals will have room for one more victim.

In this category belongs flourine in food and drink. Under present circumstances, good taste prohibits further elaboration of such a controversial subject. However, I submit two from a large group of references for the benefit of those who wish to form their own opinions. A new book by Martin[16] has an excellent chapter on Enzymatic Inhibition by Chemicals, and Spira[17], of London, describes Osteoporosis and Osteosclerosis of the Petrous bone. This was due to a disturbed calcium metabolism resulting from disarrangement of the parathyroids brought about by chronic fluorine poisoning from food.

We can rightfully inquire if the jaw bones would also suffer the same symptoms, and what influence such a condition would have on dentures.

In the realization that we too wish to survive, let us spend an equal amount of time and effort on the matters discussed as we do with the mechanical phases of dentistry.

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TO KEEP PICKLING SOLUTION FREE FROM IRON CONTAMINATION

Coat a pair of tweezers with several coats of liquid latex.

Note. It cannot be used in a flame.

—Harry Burger

UPPER AND LOWER IMPRESSIONS

To enhance the flow of impression materials (zinc oxide-eugenol pastes). The addition of eugenol to the mix (approximately 3 drops per ½ inch of material) produces closer adaptability of the material with less distortion of soft tissues. This is accomplished through the lessening of surface tension as well as by making a more fluid mix.

Escape gates or reliefs should be placed over the most easily displaceable areas, as well as in areas where material is most likely to be trapped, in other words, in the deepest part of trays.

—Charles S. Ballard

PLASTER DRILL

An easily made and inexpensive drill for removing plaster or stone may be made by flattening the head of a finishing nail with a file or stone. Grind two cutting edges on this flattened surface to form a very broad V. This drill may be used in the chuck on the lathe. It will cut quickly and will not clog. It can also be used for drilling plastics. If assorted sizes are made you will always have one that will meet the requirements at hand.

—Jerome Strain

THE PHYSIOLOGIC APPROACH TO PARTIAL DENTURE DESIGN

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IN PARTIAL DENTURE work, as in all branches of dentistry, the masticating mechanism must be considered as a physiologic unit. Steffel[1] pointed this out when he referred to it as a new concept of dentistry. The physiology of mastication and deglutition involves the teeth and their supporting tissues, the underlying bone, the temporomandibular joint, the muscles of mastication, the tongue and facial muscles, the palatal and pharyngeal muscles, and the salivary glands. The partial denture must be integrated into this mechanism structurally and functionally.

Professional partial denture service may be divided into three phases: the planning phase (often referred to as diagnosis), the preparation of the mouth, and the designing of the partial denture. This discussion is limited to the designing phase, but the importance of the first two phases should be emphasized. Planning, or making the diagnosis, involves the use of complete mouth roentgenograms and study casts which should be mounted. A tentative design must be worked out in the planning phase, and the necessary extractions, restorations, and modification of tooth contours planned. The preparation phase is then carried out according to this plan. When it is complete, the master casts are made, and the designs are made on the master casts.

Designing in any field—architecture, engineering, etc.—consists of making a careful drawing and writing exact specifications. Similar procedures should be the professional responsibility in partial denture work. The cast should be carefully surveyed and a careful drawing of the partial denture should be made in indelible pencil on the master cast. In addition, the laboratory should be supplied with detailed instructions as to materials, thickness of materials at various points, and any other specifications needed to supplement the design drawn on the cast.

Partial dentures must be designed with consideration for forces exerted in function, and for the effect of these forces on the health of the remaining teeth. The amount of bony support of the abutment teeth and the health of the supporting tissues must be evaluated carefully. The local factors which contribute to a breakdown of the periodontium and the edentulous ridges must be kept in mind. Much is unknown of the etiology of periodontal disease; however, we do know that heavy stress (especially the lateral components of such stress), food impaction,

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The opinions or assertions contained herein are the private ones of the writer and are not to be construed as official or reflecting the views of the Army Dental Corps.

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embarrassment of the circulation to the free gingival margin, and occulsal interferences all contribute to the breakdown of the periodontal tissues. The partial denture must be designed to minimize the occlusal forces, to buttress the remaining teeth against especially destructive lateral components of these forces, to avoid interference with the circulation to the gingival margin, to anticipate a slight functional movement of the appliance, and to disturb as little as possible the normal excursion of food over the tooth surfaces and gingival margins. This approach to partial denture design we have labeled the physiologic approach. In this article we formulate ten fundamental principles by which partial dentures should be constructed, and present a few examples of designs which conform to these principles. The multiplicity of designs and techniques in partial denture work is one of the reasons for confusion in this field; however, the principles are inviolate. Many designs conform to the ten basic principles, and many do not in one way or another. Techniques may vary, but the principles can be applied to any partial denture and the designs and techniques can be modified to conform.

EFFECT OF STRESSES ON TISSUE

We know that stresses applied in the direction of the long axis of a tooth are well tolerated, and that heavy lateral stresses cause severe disturbances in the supporting tissue. Orban[2] says, "crushing of the periodontal membrane, bleeding, necrosis, and bone resorption are the result of lateral forces acting upon the teeth." This is apparent when the minute structure of the periodontal membrane is studied. The fibers suspend the tooth in the alveolus so that all fibers are resisting force when vertical stress is applied. Not only are less than half the fibers resisting the lateral stress, but these fibers are obliquely positioned, and they are not stretched throughout their length in resisting the force. This must be kept in mind while designing partial dentures, and the design must be evolved to minimize lateral stresses, to distribute lateral stresses over as many teeth or as much tissue as possible, and to build the occlusion so that lateral stresses are avoided.

The edentulous ridge, like the supporting tissues of the teeth, tolerates vertical stress well but breaks down under heavy lateral stresses. DeVan[3] points out the similarity of the architecture of edentulous alveolar bone and the weight-bearing bony parts of the skeleton, such as the head of the femur. Such bone with a heavy trabeculated structure and a thin cortex is adapted to withstand compressive stress such as vertical force on a denture base would produce. Lateral forces cause shearing and torsion which cancellous bone is not adapted to resist.

THE OCCLUSAL REST

The occlusal rest must be designed to support maximal functional loads without distortion or breaking, must direct the force of occlusion in the direction of the long axis of the tooth, and must be able to move slightly without locking as the denture moves in function. In posterior teeth, the rest preparation is no great problem. The rest preparation is made well in from the marginal ridge and concave

in all directions (Fig. 1). If the rest preparation can be made deep enough without penetrating the enamel, no restoration is needed. If the rest is made in an inlay or crown, the tendency is to make it too deep. The rest should never lock in like a precision attachment, but should be able to move slightly as the denture moves slightly in function. It should be hemispherically concave; a small round diamond

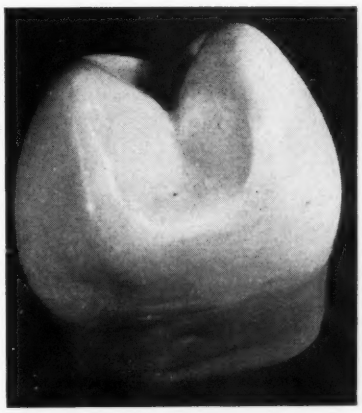

Fig. 1.—Rest preparation in a posterior tooth without a restoration. The preparation is cup-shaped and is prepared with a small round stone or diamond point.

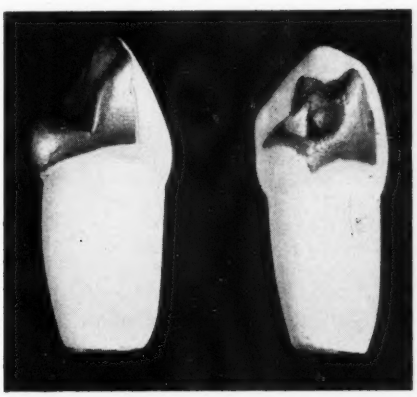

Fig. 2.—Rest preparations in restorations in anterior teeth. Ordinarily the thickness of enamel in an anterior tooth does not permit a rest preparation on the lingual surface which would direct the forces of occlusion in the direction of the long axis of the tooth.

or stone makes a concavity of ideal shape which needs only to be reduced and rounded over the marginal ridge.

In anterior teeth, the placing of a rest which will direct the force along the long axis of the tooth is more of a problem. A lug on the inclined lingual slope of a cuspid or incisor will direct the force of occlusion not in the direction of the long axis of the tooth but in a lateral direction, and produce a damaging lateral

force. The placing of a rest on an inclined plane of an anterior tooth cannot be condemned too heavily. The placing of a suitable rest on an anterior tooth often requires an inlay or a three-quarter crown in the tooth. The rest preparation in the restoration can be made cup-shaped as in posterior teeth or wedge-shaped across the cingulum (Fig. 2). When the occlusion permits, (as it sometimes does in lower cuspids) an incisal hook can be used as the rest. Hardy[4] has suggested a grooved-type rest preparation on anterior teeth which makes an excellent rest, and saves cutting into the tooth for a restoration in cases where the occlusion permits its use (Fig. 3). Other preparations in the enamel have been suggested, such as ledge-shaped cuts at the incisal angle or at one side of the cingulum, but these do not offer sufficient bulk and are too far off the central long axis of the tooth.

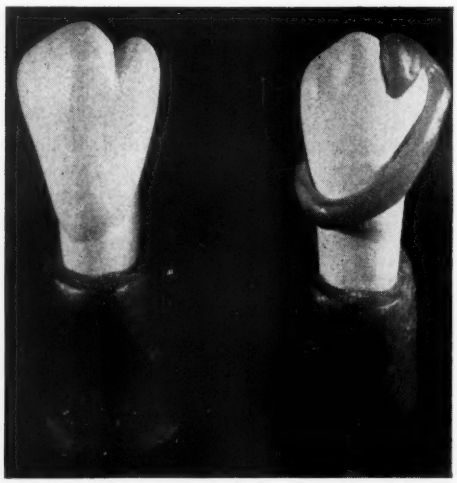

Fig. 3.—A preparation for an incisal-hook type of rest is very useful in lower cuspids where the occlusion permits sufficient bulk for a strong rest. This rest is used by Hardy, and is about the only type of preparation in anterior teeth which will give sufficient bulk of metal to form an efficient rest without placing an inlay or crown in the tooth.

CLASPS

Rests transmit vertical forces to the abutment teeth; and, as we know a tooth can withstand very heavy vertical stresses, it is not necessary to have multiple occlusal rests to distribute this stress. However, lateral forces are different. We must always distribute the lateral forces over as many teeth as possible so that the deleterious effects of these forces are well diluted. Not only is the lateral force destructive to the investing tissues of the tooth root but, as has been mentioned, it is also very destructive to the edentulous ridge under the saddles. If the teeth take up this stress, the bony ridge is spared.

The clasps are the units which resist lateral stresses. There are many ways of designing clasps with a view toward wide distribution of the lateral stresses.

The bar clasp and the wrought wire clasp are poor in their resistance to lateral stress, but are resilient enough to provide retention and yet allow slight movement of the saddles on the resilient mucosa without transmitting this movement to the clasped tooth. The circumferential cast clasp transmits the lateral stresses to the abutment teeth, but when the clasp arms engage the undercut, the clasp takes an

Fig. 4.

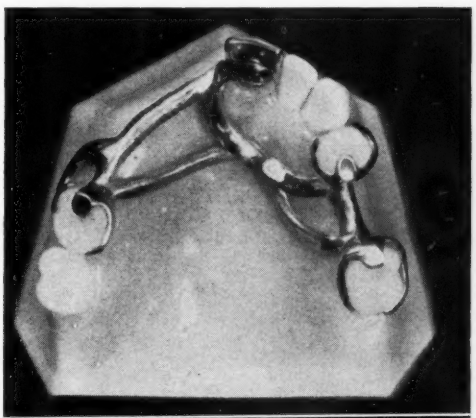

Fig. 5.

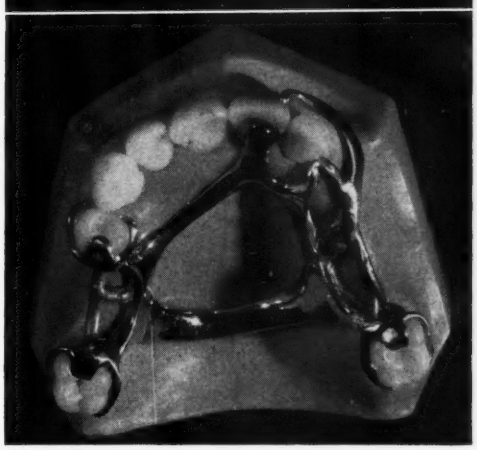

Fig. 4.—A bar-type clasp arm is used in conjunction with a heavy cast lingual arm which is placed above any undercut area. This is used where the undercut is adjoining the edentulous space, and a wire clasp arm would not give retention. On the opposite side are clasps with wrought wire buccal arms used with heavy cast lingual arms.

Fig. 5.—A method of securing a positive rest seat and a retentive clasp where the cuspid is missing. The lateral incisor is by-passed, and a bar-type clasp arm is brought into the distolabial undercut of the central incisor. An inlay is placed over the cingulum of this tooth, and a cup-shaped rest is prepared in the inlay.

unyielding grip on the tooth and should not be used in conjunction with a free-end saddle. Stress-breakers have been used in an attempt to overcome this objection, but they are objectionable in themselves for various reasons. Stress-breaking devices are a laudable attempt to solve the problem of stress distribution between the comparatively rigid abutment and the displaceable mucosa; however, most of these

devices are complicated, delicate, and expensive. It is our belief that, for most operators, a clasp which does not rigidly embrace the abutment tooth is a more practical solution.

A simple solution to the clasp problem is the use of a cast clasp arm for resistance to stress on one side of the abutment tooth, and a resilient wire arm on the opposing side for retention.[4] The cast arm is kept heavy and *out of any undercut area* so that it can move on the tooth slightly in function. The wire arm used is of a platinum alloy, and is incorporated in the wax, and the framework is cast

Fig. 6.

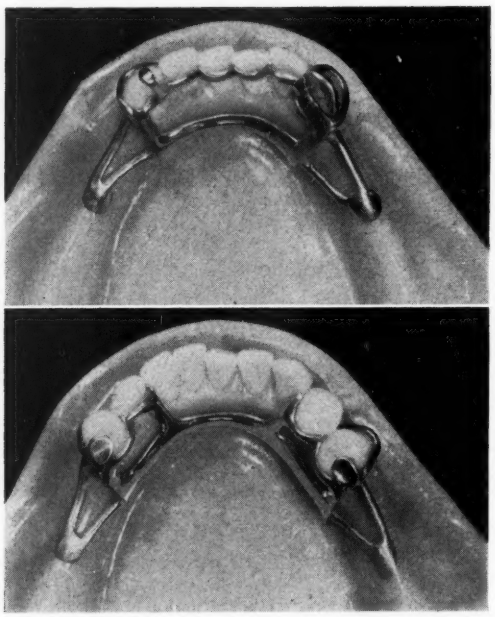

Fig. 7.

Fig. 6.—A Kennedy bar with an incisal-hook rest on one abutment, and a cingulum-type rest prepared in a three-quarter crown on the other as in Fig. 2. The Kennedy bar distributes lateral stresses over a number of teeth and is valuable from that standpoint. The Kennedy bar is not a rest, and rest preparations on the abutments must be used with it. The labial clasp arms in this framework are wrought wire arms which have been incorporated in the casting.

Fig. 7.—A modification of the Kennedy-type bar which distributes lateral stresses over four teeth instead of only the two abutments.

to the wire arms. Often the undercut area most favorable for retention cannot be utilized with a circumferential clasp. In these situations, a bar-type arm is used in place of the resilient wire arm, reciprocated with a heavy cast arm out of the undercut area (Figs. 4 and 5). This type of clasp, of course, resists lateral stresses only in one direction, but the clasps on opposite sides of the arch reciprocate each other in this respect. This type of clasp is easily adjusted, and is kind to the abutment teeth. With only the resilient wire arm or the bar-type arm in the undercut

area, the clasp will move slightly on the tooth in function. The circumferential cast clasp, with its rigid arms of hard gold extending into undercut areas, cannot be too heavily condemned when used in the free-end saddle denture without stress breakers.[5,6]

There are ways to spread the lateral forces over more teeth. The Kennedy-type bar or a modification of it with short extensions (Figs. 6 and 7) will accomplish this very nicely.[7]

The Kennedy bar or continuous clasp is not only ideal to distribute stress in the lower anterior region, but it also supports the teeth against the forces exerted upon them by the upper incisors, and so is useful in supporting weak teeth in this location. The stress exerted by the bar with functional movement of the appliance

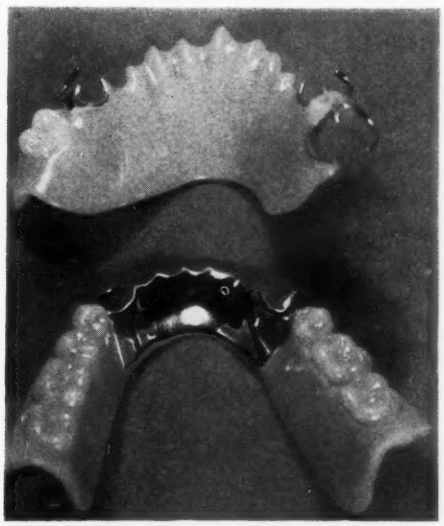

Fig. 8.—Partial dentures which violate a basic principle regarding the covering of the free gingival margin. The partial denture with the wide gold plate covering the anterior gingivae also is generally rather thin in this region so it is not rigid in a lateral plane.

is overbalanced by the support given these lower anterior teeth against the forces of incisive stress. In the upper arch, the continuous clasp would exert force in the same direction as the force from the opposing teeth. For this reason it should never be used on an upper appliance.[8] Also, the occlusion would not permit the placing of a continuous clasp above the cingula of the teeth in most maxillary arches. The continuous clasp should always be placed above the cingula of the teeth. If it is placed lower, it interferes with the excursion of food over the free gingival margin, and since it is on a more acute slope, it exerts a greater horizontal component of force. In the upper arch, a palatal connector which crosses the palate somewhat anterior to the abutment teeth (between the prominent rugae about 5 mm. or more posterior to the anterior teeth) will serve very well as a stabilizer

and a substitute for a Kennedy bar. The finger rests placed on the lingual inclined planes of anterior teeth which are called "indirect retainers" should not be used. They exert deleterious forces on these teeth in function; they serve to complicate the design; and it is very doubtful if they add anything to retention, even in an indirect manner.

While discussing clasps, it should be mentioned that excessive tilting of the cast in the instrument when surveying should be avoided.[9] A direction of insertion should be selected which is parallel to the principal vertical occlusal stresses, and the mouth should be prepared on the basis of such a path of insertion. The prosthesis must move slightly under function, and this path of insertion will best allow such movement without exerting lateral or prying forces on the abutments.

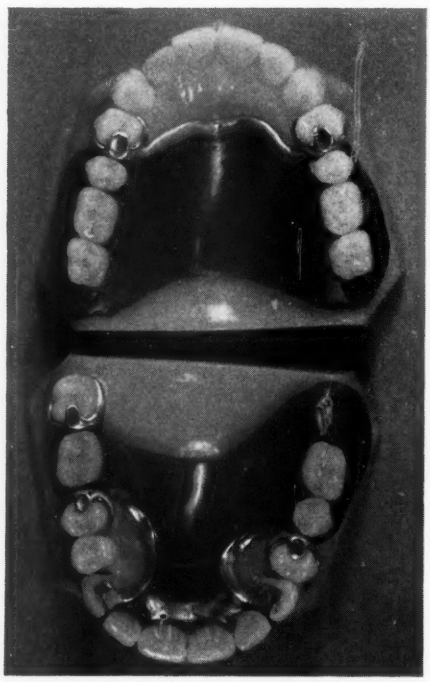

Fig. 9.—Bases made to cover a wide area of mucosa for stress distribution, and yet not cover the marginal gingival tissue. Note that the posterior denture teeth have been reduced in width buccolingually so that resistance in passing through the food bolus is lessened, and less stress is transmitted to the base.

BARS AND CONNECTORS

Lingual and palatal bars *must be rigid* to transmit lateral stresses to the various parts of the denture so these stresses will be distributed over as many abutments as practicable. This is one of the basic principles and should never be violated. We must avoid covering the gingival tissues of the remaining teeth with bars or base material. This point cannot be overemphasized. It is also a basic principle.

It is of the utmost importance to the health of the remaining teeth that these tissues be uncovered, yet many partial dentures are designed which violate this principle (Fig. 8). Some authors[10,11] mention this principle, and specify 3 mm. as the minimum distance by which the bases and bars should avoid the free gingival margin. Twice this distance is a better rule (Fig. 9).

The harm that overhanging crown margins and overhanging fillings do to the gingival tissue is recognized by everyone practicing dentistry, yet many partial dentures are made which cover the free gingival margin and produce the same effect (Figs. 10 and 11). Gingivitis caused by mechanical irritants is one of the most frequent findings in the oral cavity. The gingival tissue is so constructed that the blood supply is easily diminished by mechanical interference. Any pressure of the base on this tissue will surely lead to a chronic irritation. Even covering this tissue is strongly contraindicated, as it is obvious that the gingival tissues need normal stimulation of surrounding tissues and food during mastication to maintain the hornification[12] needed for health.

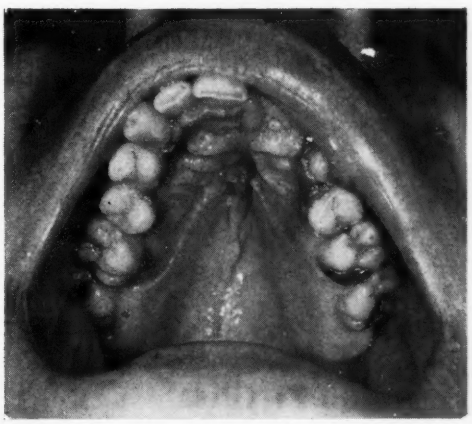

Fig. 10.—Typical gingival irritation caused by the denture base encroaching upon the gingival margin. The tissue around the necks of the teeth covered by the denture base is chronically inflamed, hypertrophic, eroded, and hemorrhagic. The gingival tissue posterior to the area covered by the base is normal; the palatal tissue covered by the base is normal appearing, although it is marked where the denture periphery terminates. Only one conclusion can be drawn: never cover gingival tissue with a base or connectors.

SADDLES

Partial denture saddles must meet three requirements: they must cover as much area as possible, they must avoid covering the free gingival margin, and they must accurately fit the tissue surface. The first requirement is accomplished if the saddle is designed to cover as much area as a full denture would include in that segment. The second requirement, as was mentioned in discussing bars, is the principle of avoiding coverage of the free gingival margin, and it is an important one. It is understandable that technicians would fail to recognize the dangers of covering this tissue, but it is hard to understand anyone with a background of periodontology

creating such a design. The third requirement, adequate tissue adaptation of the saddle, is dependent upon the accuracy and type of impression made. With normal tissue, a carefully made hydrocolloid type of impression will be sufficient to get a stable fit for the free-end saddle. Although a functional impression or relining is not always necessary, it is never undesirable.[1] With a large amount of soft tissue over the ridge, it is always desirable to get the tissue registered under some stress. This can be done best by relining the saddle under biting stress after the partial denture has been finished. An impression wax is best for this.

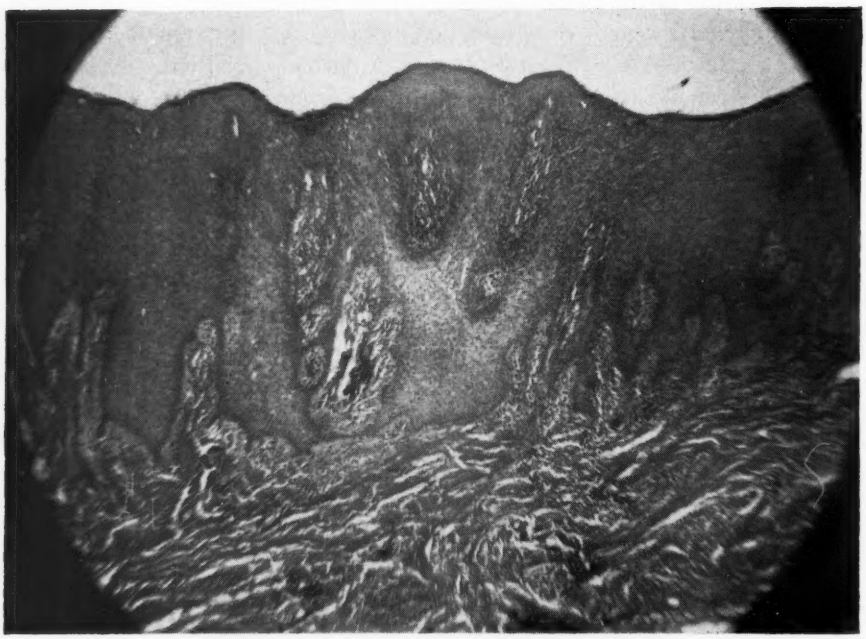

Fig. 11.—The microscopic picture of the gingival tissue in Fig. 10 shows acanthosis of the epithelium, with a chonic inflammatory reaction in the papillary layer of the corium, and proliferation and enlargement of the blood vessels.

THE TEETH

The principles of occlusion followed in full denture construction should be just as conscientiously followed in partial denture construction. The importance of re-establishing true centric relation should be emphasized. In partial denture construction, we must establish centric occlusion at the centric jaw relationship. Sometimes the remaining natural teeth must be modified, and restorations placed in them to restore this relationship, preparatory to constructing the partial dentures. The most common discrepancy is an anterior relationship of the mandible to the maxilla with abrasion and stress on all teeth, and especially on the remaining upper anteriors.

In partial dentures, a well-balanced occlusion is sometimes difficult to obtain, but we can reduce cusp height and avoid occlusal intereferences to minimize lateral stresses. We can also keep the artificial teeth to the lingual side of the edentulous ridge, and strive for unilateral balance.[13]

The occlusal table should be reduced buccolingually so a cutting action rather than a mashing action is developed by the supplied teeth (Fig. 10). Again, this is done with the thought of reducing stresses on the base and on the remaining teeth.

SUMMARY

Impression making is an extremely small part of the professional service rendered in partial dentures. The planning and diagnosis for partial dentures and the preparation of the mouth have not been within the scope of this article. However, the importance of these steps is emphasized. The professional service in partial denture work consists of three steps: planning (diagnosis), preparing the mouth, and designing. To properly design a partial denture requires a background of periodontology, oral histology, and physiology. The construction of a partial denture is a mechanical operation, but the designing of a partial denture is not.

The principles of partial denture construction are summarized as follows:

1. Provide adequate support on the remaining natural teeth to resist vertical stresses, and to direct those stresses in the direction of the long axes of the abutment teeth.

2. Provide broad coverage of saddle areas so the stresses borne by the soft tissues are distributed over a large area.

3. Provide adequate tooth-borne resistance to lateral stresses (adequate both in rigidity and in number of teeth engaged, so that this stress is distributed over a number of abutments).

4. Provide adequate retention.

5. Provide for distribution of stress between the relatively rigid abutment teeth and the relatively resilient saddle areas.

6. Have rigid bars and connectors.

7. Avoid covering the free gingival margin around the remaining teeth with denture base or connectors.

8. Decrease the occlusal table by using narrower artifical teeth and fewer teeth.

9. Provide harmony of the occlusal surfaces of opposing teeth, both natural and artificial (this includes recording true centric relation, obtaining as balanced an occlusion as possible, and reducing cuspal inclines to minimize lateral stress).

10. Place the denture teeth over the ridge or lingual to it.

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MAKING A COIL SPRING

Select a spindle or rod about one-third the diameter of the finished spring. Suspend the rod between two uprights (like a shaft). Chuck both rod and wire in the jaws of a small Miller Falls hand drill. Spin the wire on spindle, as if you were wrapping a fishing rod. Remove the spindle and cut the spring to the desired length. Stainless spring steel wire No. 7, diameter 0.018 inch, is a good average size.

—Charles Lipp

TEMPORARY CEMENTATION

Quick curing plastic splints may be cemented with Ward's Wonder Pack for temperature protection in extensive abutment preparation.

—A. R. Guthrie

AN ANALYSIS OF THE USE AND RELATIVE VALUE OF THE PRECISION ATTACHMENT AND THE CLASP IN PARTIAL DENTURE PLANNING

CLYDE H. SCHUYLER, D.D.S.

New York, N. Y.

WHILE REPLACING missing teeth by artificial substitutes, our primary objectives must be the restoration of oral health, oral function, and esthetics. Not all dental replacements satisfy these objectives. In fact, too many partial dentures are made with negligible consideration or planning other than a desire to fill a void where natural teeth have been lost, with the result that esthetic values are very limited, and from the time of insertion, the appliances contribute to the premature loss of remaining natural teeth and alveolar support.

Every worthwhile machinist, engineer, or architect recognizes the existence of certain basic fundamental principles or laws that must be recognized and compensated for, or his handicraft will be of little or no value.

When the dentist fails to recognize biomechanical laws, the product of his exquisite artisanship may not qualify as a restoration as, instead of restoring oral health, function, and esthetics, it rapidly contributes to oral pathology with subsequent loss of function and esthetics. The dentist too frequently discusses needed dental restorations, outlining the plan of treatment and costs based upon snap judgment. The physician recognizes his diagnosis and plan of treatment as one of the most valuable services he can render to his patient. It is a service worthy of compensation. Diagnosis should receive equal consideration in the practice of dentistry.

Roentgenograms are essential in determining the presence of foci of infection, value of alveolar support, dental caries, etc. But without mounted study casts, it is impossible to determine factors of occlusal disharmony, abnormal position or inclination of teeth, undesirable tooth contours, and other factors which complicate oral rehabilitation.

A careful and complete oral examination with complete oral roentgenograms and study casts mounted upon an adaptable instrument should be the minimum requirement in the planning of an oral restoration. Often this should be supplemented by a careful discussion of general health, mental reactions, and oral prophylactic treatment.

Diagnosis and treatment planning with an explanation of the needed treatment will quite normally consume two or more hours of a dentist's time. The dentist, like the physician, should receive a reasonable compensation for this

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diagnosis and outline of treatment regardless of whether or not the patient accepts his prescribed treatment. As with the physician, diagnostic costs can be given in advance. Treatment costs must be based upon final diagnosis and plan of treatment. As the dentist recognizes the logic of this procedure, he will progressively render a greatly improved health service.

Our mind should always be focused upon the services essential to restore and maintain maximum function and health to the entire oral mechanism, and not upon the replacement of a filling or a tooth. The fixed bridge provides the most acceptable means of replacing teeth when satisfactory abutment supports are present. When the removable partial denture is essential, the precision attachment provides the most equitable and definite means of distributing stresses, and in some instances it is by far the most satisfactory means of replacing teeth with reasonable certainty that oral health can be maintained. It eliminates the necessity of the unsightly labial clasp arm.

Unquestionably, the most common defect in planning the clasp appliance is the placing of lugs upon the lingual incline of anterior teeth without a specially prepared lug seat. A lug placed upon the incline of an anterior tooth causes horizontal wedging or stresses to be projected upon not only the anterior abutment but upon all abutment teeth. A properly prepared lug seat will eliminate the possibility of this destructive wedging, and aid in directing stresses parallel to the long axes of the abutment teeth. Inlays in anterior teeth with definite lug seats add little to the cost of such a restoration but greatly increase its value.

The great advantage of precision attachment appliances over those retained by clasps is not only the elimination of wedging, but the fact that all horizontal stresses are most favorably distributed. The attachments virtually tie abutment teeth together in a way that not only horizontal stresses are distributed between all abutments, but the excessive movement of abutment teeth in function is limited, and abutment teeth give support to each other.

Precision attachment restorations have commonly been constructed with rigid palatal or lingual bars, while the connecting bars of the average clasp appliance have been much too flexible. A flexible bar precludes the possibility of a bilateral distribution of horizontal stresses or the stabilization of abutment teeth. Too flexible or poorly planned clasps have little value in bilaterally distributing horizontal stresses.

The attachment restoration has required precision in planning in chair operations, in laboratory construction, in fitting and in maintenance, while the clasp partial denture service has been rendered with shameful negligence in planning or workmanship of construction. While the attachment appliance presents in many cases definite advantages, the willful abuse of the clasp appliance has contributed to its disrepute. An effort to replace lost teeth for minimum costs has too often caused some to lose sight of, or to disregard the paramount objectives; i.e., long-range mainenance of oral health and function. The result is seldom an economical service for the low-income patient. It often parallels the adage of "penny-wise and pound-foolish." I do not mean that all appliances must be precision attachment appliances. Clasp appliances must be constructed with due consideration to the factors controlling their success or failure.

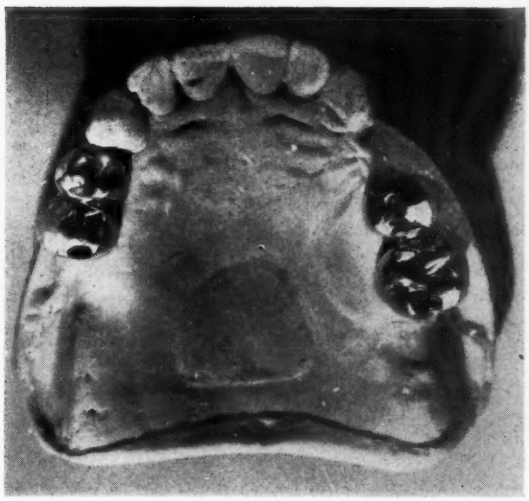

Fig. 1.—A cast with the fixed restorations of teeth in place in preparation for the construction of a removable appliance which will be retained by lingual clasp arm in combination with deep, slightly tapered locked rests. The deep rests are parallel to the long axes of the teeth. They are slightly tapered and do not require the same accuracy in parallelism as precision attachments. The lingual surfaces of the restorations are contoured for the retention of the lingual clasp arm.

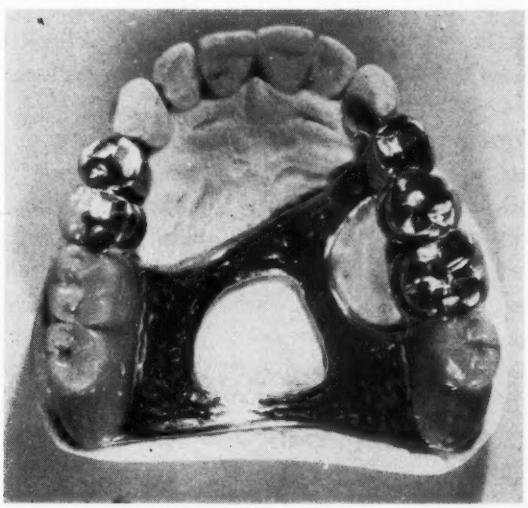

Fig. 2.—The completed restoration in place on the cast. The combination of the deep rest seat with the lingual clasp arm possesses most of the advantages of a precision attachment. This attachment causes the patient less trouble in learning to insert and remove the appliance than does the usual precision attachment. The Sherer Spring Locked Attachment also possesses all the advantages, without some of the disadvantages of the common precision attachment. It can be used with the lingual retentive arm replacing the spring.

The partial denture supported by clasps can be so designed and constructed that the distribution of the stresses of mastication, both vertical and horizontal, will be approximately as harmless to abutment supports as those constructed with precision attachments. This requires the use of inlays with definite lug seats on all anterior abutment teeth, a careful analysis of clasping techniques with proper selection and positioning of clasp arms, rigidity of connecting bars, adequate coverage, and proper adaptation to ridge or palatal areas. In some free-end saddle cases the properly designed clasp may place less leverage upon abutment teeth than would the precision attachment (Figs. 1 and 2).

Years of experience with precision attachments have caused me to recognize the advisability of using a lingual, half-round wrought wire clasp arm in connection with the precision attachment for retention purposes. As precision attachments wear, they supply insufficient retentive values. An adjustment of the slightly flexible clasps arm readily provides the needed retention.

Another factor which has, in general, contributed to clasp denture failure is the fact that the abutment teeth are seldom properly prepared to receive a clasp appliance. Only by making a careful survey of mounted study casts can the essential preparatory work be determined. This consists of not only occlusal preparations for occlusal rests (inlays in anterior teeth with definite lug seats have been discussed), but a reduction of some axial walls to eliminate excessive tooth contours and to more nearly parallel abutment teeth, thus making it possible to favorably position clasps for the maximum retention and distribution of horizontal stresses. The reduction of proximal surfaces should not expose dentine, and all corrected surfaces should be highly polished.

In all types of restorative dentistry, a favorable distribution of occlusal stresses and a reduction in the steepness of occluding tooth inclines is imperative as a factor in reducing horizontal or lateral stresses and an essential in maintaining oral health.

Success in restoring the partially edentulous mouth depends perhaps more upon how we use the materials at hand rather than what we use. Restoring and maintaining function and health of the partially edentulous mouth is one of the most complex and exacting services the dentist is required to perform. It requires a knowledge of biomechanical factors, vision, judgment, originality, resourcefulness and, above all, a will to do what the conscience dictates to be in the best interest of the patient.

Every patient should be impressed with the value of oral cleanliness and the necessity of periodic prophylactic care. The maintenance of mouth health by periodic prophylactic care is much less time consuming and painful than periodic rehabilitation.

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AN ESTHETIC MASKING CEMENT FOR PROSTHETIC DENTURE CLASPS

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ACRYNAMEL CEMENT is a relatively permanent, insoluble (in oral fluids), neutral, opaque, dental filling cement which sets with unusually great adhesive power in approximately five minutes. It was used in this study as an esthetic coating for metallic denture clasps.

Tests have been performed by the manufacturer[1] to study the ability of the new cement to adhere to unpolished metal, wood, stone, bone, ground glass and smooth glass, unground tooth enamel, ground enamel, and dentine. Specimens were wet and dried alternately daily for a total of six weeks, frozen, frozen and boiled, boiled, boiled and frozen, struck with a four-ounce metal mallet, and tested with a steady hard force. All adhesion tests were reported to be successful except those with smooth glass.†

METHODS

After successful preliminary trial on discarded denture clasps, 161 partial denture clasps in function (including 78 dentures of 67 denture patients) were treated experimentally. Each clasp had previously been constructed without consideration for the present technique. Of the 161 clasps, 77 were bar type and 84 were circumferential. Of the circumferential clasps, 52 were constructed of cast white gold, and 32 were of 18-gauge wrought gold wire; 52 of the bar clasps were of cast gold and 25 were of half-round wrought wire. Wrought dentures were constructed with Stern's No. 3224, 14 percent platinum white gold. Stern's 14 percent casting gold was used for all cast dentures.

Only dentures which had already served satisfactorily in the mouth for periods of at least two months were used. Approximately ¼ inch or more of the terminal portion of each clasp was prepared to receive the Acrynamel overlay. The denture gold was first ground lightly, on the labial surface only, with a carborundum stone. Then a Joe-Dandy disc was used to cut a series of parallel retention grooves on the labial surface only of the terminal portion of the denture clasp approximately ½ mm. deep and as close together as possible, each cut still retaining individuality. The tooth contacting surface of the denture clasp was left intact. The denture clasp was then washed and dried thoroughly.

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†Controlled laboratory determinations of the physical properties of Acrynamel are now in progress in our laboratory.

Acrynamel powder and liquid were mixed on a disposable paper mixing slab with one-half of a wooden tongue depressor broken lengthwise. (This was done to avoid the difficulty of removing set cement from a glass slab and spatula.) The liquid was dispensed from an eye dropper over a small portion of powder until an extremely soft wet mix was obtained. The mix was relatively slightly looser than that used in the cementation of inlays. The readily flowing mixture was spatulated briefly for uniformity of mix only. The material was carried quickly (within fifteen seconds) to the denture clasp by means of the tip end of the broken tongue depressor and applied to the labial surface only. It was placed as an even coating over the surface to restore the full original contour and shape of the denture clasp. The denture was then put aside for twenty-five minutes without conforming pressure or other disturbing factors to allow the material to set completely, although the set usually takes place within ten minutes. (The coating may be disked lightly and polished without danger at a subsequent visit.) The denture was then reinserted into the patient's mouth. The ease of insertion, ease of removal, and occlusion were rechecked. Each patient, previously advised of the possible benefits of the preparation, was instructed to use some additional care in the removal of the denture so as not to put unreasonable strain on the masking cement. The patients' dentures were subsequently examined periodically to determine the success of the technique.

RESULTS

The evaluation of the clinical success of this procedure appears as Table I. Of the 161 restorations, 129 were seen at the end of a six-month period. Of these, 47 were considered complete failures since the masking material had come away from the denture clasp entirely after varying periods of time. These failures are thought

TABLE I. PERIODS OF SUCCESSFUL SERVICE OF ACRYNAMEL COATING OF PARTIAL DENTURE CLASPS (67 PATIENTS).

	CAST		WROUGHT	
TYPE OF DENTURE	CIRCUMFERENTIAL	BAR	CIRCUMFERENTIAL	BAR
Number of clasps prepared	52	52	32	25
Number of clasps examined at:*				
One week (total)	48	52	29	25
Failed	3	3	3	2
Chipped	5	4	4	3
Remained as applied	42	45	22	20
One month (total)	44	49	28	25
Failed	5	4	3	5
Chipped	4	4	5	5
Remained as applied	35	41	20	15
Two months (total)	41	42	26	23
Failed	6	6	4	6
Chipped	6	7	6	5
Remained as applied	29	29	16	12
Six months (total)	41	40	25	23
Failed	14	14	10	9
Chipped partially	11	10	6	6
Remained as applied	16	16	9	8

*Some of the patients were examined at some but not all of the examination periods.

perhaps to have resulted from faulty preparation of clasps in the early cases in the series, delay in the application of the cement to the clasp, or an application of slightly too thick or too thin a mix with insufficient bulk in some cases. The cement on 33 clasps was noted to be chipped while 49 clasps remained of approximately the same appearance as at the time of application except for normal accumulations of oral stains and debris. Over shorter periods of time, the percentage of overlays remaining as applied was progressively higher (see Table I).

Success in the application of the overlays increased as experience in the proper technique of preparation of clasps, mixing the cement and applying the overlay was gained. A further clinical observation was the increased percentage of success with those individuals who took especial care in their "treatment" of the overlays. These were usually those individuals most desirous of continuing the improved esthetic appearance. No breakage of clasps occurred in the area of clasp preparation.

The ease of application is such that after having once prepared the clasp, a reapplication of the cement requires only seconds. The cement might be dispensed to the patient, if desired, allowing him to apply the material to the denture when it is required, just as he might apply a cosmetic.

No instance of irritation to teeth or oral mucous membrances was noted in the course of this study. Since Acrynamel has been used as a permanent filling material, there is little reason to fear its effect upon the intact exterior of the tooth, especially since the Acrynamel coating does not actually come into contact with the tooth. No processing is required, and compression of any type is contraindicated. Use of this cement in newer, more varied, and natural shades to mask metal in other areas and functioning in other capacities in the mouth is now being studied. Adhesion to cast stainless steel clasps was not satisfactory, and does not seem to be indicated.

This effort at improving the esthetic appearance of partial dentures was well received by the patients. Improvement in the technique of clasp preparation and cement application or alteration in the formula might well improve greatly the results to be expected.

SUMMARY

Acrynamel cement, a relatively opaque dental cement with unusually great adhesive characteristics, was used with considerable success as an esthetic masking coating on the terminal portion of 161 denture clasps. The nonirritating overlay is placed at the chair, sets in ten to twenty-five minutes and has an appearance considerably superior esthetically to that of denture gold. A simple technique for its application is described.

REFERENCE

1. Unpublished data of the manufacturer: The liquid is a methylmethacrylate monomer familiar to dentistry. The powder is activated to physically melt into the monomer which bonds the mass. The final cement is inert and harmless and can be ingested with no ill effect. While liquid, the setting mass has a pH of 6.9 to 7.

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Acrynamel for this study was supplied by the American Consolidated Dental Co., Philadelphia, Pa.

FIXED BRIDGES WITHOUT SOLDERING

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THE TECHNIQUE to be described saves time, eliminates the difficulties encountered in soldering, and produces a one-piece cast bridge. The resulting bridge is as anatomically near to the original dentition as possible, without sacrificing the desired qualities of fixed bridgework.

In his recent article describing an ingenious technique for the construction of temporary acrylic bridges, Leff[1] states that some of these subsequently have been cast in gold in an experimental attempt to eliminate the necessity for the soldering of fixed bridgework.

A significant difference between a permanent and a temporary bridge is that the former requires a perfect extension and fit of the retainers (crown, inlays, etc.), whereas, adequate coverage, satisfactory retention, and good cosmetic appearance are the only necessary features of the latter. Permanent restorations require an accurate working cast, with dies exactly reproducing the relationship of the abutment teeth for the final shaping of the acrylic pattern. The procedure used in the initial stage of the construction of the acrylic pattern resembles the one employed by Talkov[2] for his temporary bridges and splints. The applicability of the Leff's technique has not been tested yet for permanent bridges; however, it seems to be promising.

THE TECHNIQUE

1. The missing tooth or teeth are first replaced on a study cast. They may be carved in wax; or porcelain or acrylic teeth may also serve the purpose. The most economical are wax or plaster teeth which are produced easily in the laboratory by using a commercially available rubber mold. In addition, any desirable changes or corrections in the anatomy of the abutment teeth (occlusal surface, contact points, etc.) are made by carving or waxing.

2. The abutment teeth are then prepared, and copper band impressions are made in the usual manner. A plaster impression is then made. This rigid impression will allow accurate reproduction of the relationship of the abutment teeth. A wax checkbite is obtained for the occlusal relation with the opposing arch. A precise working cast (preferably with amalgam dies) is later constructed in the laboratory.

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3. An alginate impression of the involved part is then made from the waxed-up study cast. A self-curing acrylic is mixed and filled in the dried alginate impression. This is seated in the patient's mouth over the well-lubricated abutment teeth. After the necessary curing time of the acrylic has elapsed, the alginate impression is removed. The resulting acrylic bridge is trimmed and withdrawn from the mouth to be used as a pattern after further finishing. A temporary bridge can be produced, if desired, by using the same alginate impression and repeating the procedure.

4. The acrylic pattern is transferred to the working cast. The peripheries of the retainers are then accurately adapted to the dies, and extended as much as necessary. Any desired changes can be made easily by grinding or waxing. The pontics can be shortened to a sanitary shape; windows for acrylic facings can be cut in the teeth, and provided with retention loops or buttons; backings for porcelain facings can be attached, etc. The pattern is then smoothed and polished, thus obtaining the form which is intended for the final product.

5. The pattern is sprued, invested, cast and polished. After a final try-in, the bridge is ready for cementation.

The technique described has been recently modified as follows: after the abutment teeth have been prepared, and satisfactory impressions have been obtained, the patient is dismissed with or without a temporary bridge. A working cast with amalgam dies is then constructed. The alginate impression with the self-curing acrylic is seated over the working cast. The acrylic pattern thus obtained is then trimmed, invested, and cast. This eliminates curing the acrylic in the patient's mouth.

SUMMARY

The construction of fixed bridges can be accomplished satisfactorily by casting the entire gold structure (retainers and pontics) in one piece, thus eliminating soldering. For this purpose the teeth to be replaced are first molded on a study cast. An alginate impression of the involved part of the study cast is made. This is then filled with self-curing acrylic and placed directly in the patient's mouth, or over an accurate working cast. The first method is more inconvenient for the patient; the modification, on the other hand, relies completely upon the accuracy of the working cast. The acrylic pattern obtained is, in either case, given its final shape by making the necessary adjustments on the cast. This pattern is cast in gold. The resulting bridge is in no way inferior to one produced by any other method. Naturally, the procedure offers many possibilities of error, but since there is no soldering, errors which may result from it are impossible.

There is definitely a need for more bridgework to be done by this method before final judgment is passed. However, even after the relatively short time in which the technique has been used, it can be safely stated that it has definite advantages to offer. There is a considerable amount of time saved. Weak spots in the form of soldered joints are eliminated. The procedure permits restoration of the dentition to its original form, thus avoiding interference with physiologic functional movements. The need for occlusal grinding is also minimized.

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TO CLEAN ALGINATE FROM A TRAY

Soak in a solution of Polident. Do not put aluminum trays in this solution.

—Russell H. Angsburger

ASBESTOS SOLDERING MATRIX

Keep a small jar containing asbestos fiber in denatured alcohol. Pack the asbestos around waxed units to maintain their position in soldering.

—Charles S. Lipp

MASTICATORY PRESSURES EXERTED WITH IMPLANT DENTURES AS COMPARED WITH SOFT-TISSUE-BORNE DENTURES

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THE OBLIGATION of the medical and dental professions is the maintenance of health and function of patients through prevention or restoration.

Dentistry's aim is a cure, not a palliative treatment, if that cure is possible. Therefore, I feel that the implant denture technique is the most important accomplishment for the dentist and his edentulous patient in the last one hundred years. Doctors Goldberg and Gershkoff[1, 2] should receive the gratitude not only from dentists for having this procedure placed in their hands, but from the debilitated edentulous patients as well for whom no prior hope was extended to restore them to oral health.

The objectives of prosthetic dentistry may be divided into four parts: function, comfort, esthetics, and phonetics. All of the other objectives depend upon function for success. What good are beautiful dentures if they rest in a bureau drawer or in the patient's pocket? If a denture does not perform the action for which it was made, the patient cannot speak correctly with it nor have comfort. If the substitutes are constructed to "restore as fully as possible the function of the natural organs,"[3] the other objectives of comfort, esthetics, and phonetics are accomplished. In the field of prosthetic dentistry, if all of the objectives are not carried out to the utmost, function has not been restored, and without the restoration of proper function, the procedure is a failure.

Function has been described as the "normal, special, or proper action of any part or organ."[4] In prosthetic dentistry, function is dependent upon stability and retention of the appliances, and the ability of the patient to exert the pressures necessary to masticate the foods so that they may be completely digested by the remainder of the digestive tract.

PRESSURES

Pressure is "stress or strain, whether by compression, pull, thrust, or shear."[4] Upon the contraction of the muscles of mastication, there is an exertion of pressures which develops a dynamic force in a closing direction, and at the same time an equal and opposite force is developed which is a "static force."[5] This static force must be capable of resisting the moving or dynamic force without surpassing

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the physical limitations of the materials involved. This is especially true in the masticatory mechanism, for if the pressures exerted by the muscles of mastication are within physiologic limits, no necrosis nor atrophy will occur. If the pressures are outside these limits, a loss of tissue results which causes impairment of function. Normal pressures create a stimulus which maintains the tissues in a normal, healthy condition. In the masticatory mechanism, the resistance to the moving force is the periodontal membrane, or the mucous membrane, and the submucosal tissue, or the periosteum and the osseous structure—depending upon whether the pressures are applied against the natural dentition, soft-tissue-borne dentures, or implant dentures, respectively.

MEASUREMENTS OF BITING PRESSURES

The pressures exerted by the muscles of mastication have interested many men, notably Black,[6] Head,[7] Tylman,[5] Brudevold,[8] and Boos.[9] They used various techniques of measurement of the biting forces applied by patients, and at times arrived at different results.

Boos[9] developed a gnathodynamometer which he called the Bimeter which was used to measure the biting force of edentulous patients. The Bimeter consists of a tripod base with two arms which rest on the denture base in the mandibular first molar regions, and an anterior bar which rests on the denture base at the lower anterior region, and an adjustable central bearing point. The central bearing point contains a mechanism for measuring the biting forces in points. It also equalizes the stresses over the area covered by the denture bases as it contacts a plate set on the upper base at the center of the palate. Boos states that the measurements obtained are of a relative nature only. He used the final information from the Bimeter to find the maximum "power point" in order to establish the correct vertical dimension, and to allow him to construct conventional dentures with the maximum functional efficiency.

THE MASTICATORY MECHANISM

To understand the pressures possible with tissue-borne dentures as compared to implant dentures, a brief description of the masticatory mechanism is necessary. The masticatory mechanism consists of four essential factors: (1) the maxilla (the immovable base), (2) the mandible (the moving factor), (3) the muscles which guide and move the mandible, and (4) the muscles which control the position of food for mastication. These four factors, working in unison in normal action, prepare the food in the mouth for correct introduction into the remainder of the digestive tract. However, only three of them will be discussed.

The *maxillary* bones, which are fused at the median suture with their alveolar processes into which the teeth are introduced, act as the immovable base which resists the forces of mastication.

The *mandible* is the moving or dynamic element which is brought into contact (by means of the teeth) with the maxilla by the contraction of the muscles of mastication.

The *muscles of mastication:* The temporal, masseter, and internal pterygoid muscles put the mandible in motion in a closing direction and bring it into contact with the maxilla. The external pterygoid muscles guide the jaw into various positions before and after the contact of the opposing teeth.

Under certain conditions these muscles can exert considerable force. Gysi[10] found that, in combined action, these muscles were capable of developing an average of 200 to 300 pounds of force. It was also found that the effective strength of muscles varied in different individuals.[11] With disuse, muscle atrophy occurs, and power is lost. Once it is lost, it is never entirely regained,[9] although muscle power can be increased up to a certain point. "The optimum age period for maximum pressures is between the ages of twenty and forty."[5]

THE OBJECTIVE

Comparative studies were made on one patient to determine how effective function could be restored to the edentulous patient, and the effect this function would have upon atrophied muscles and the bone beneath implant dentures.

The patient selected was a white woman, 41 years of age, 5 feet 5 inches tall, weighing 109 pounds, and with small bone structure. She had worn full upper and lower dentures since 1949. Between 1949 and May 2, 1952, she had had four other sets of complete dentures. Her chief complaint was pain on mastication which did not allow her to chew her food properly, and inability to retain the dentures in her mouth. She was understandingly very nervous, frustrated, and depressed. The alveolar processes of the maxilla and mandible were constricted buccolabially and lingually, and presented thin, sharp ridges. The intraoral tissues were apparently in good health. The patient desires a full lower implant denture, and the author believed it to be indicated. Tissue-borne dentures had proved entirely unsatisfactory for this patient.

PROCEDURE

Alginate impressions were made, and bases were constructed as suggested by Boos. A Bimeter was mounted on the lower base and a metal plate was mounted in the palatal vault of the upper base to oppose the central bearing point of the instrument. The bases were then transferred to the mouth, and the "patient was instructed to bite as hard as possible in any position that was comfortable."[11] The vertical dimension was varied until a registration of the maximum biting force was made in order to locate the power point.

The vertical dimension, measured from the base of the nose to the chin, was maintained at a constant 118 mm. for all registrations.

The patient exerted an average pressure of ten pounds with her tissue-borne dentures over a period of time. This is far below the average range of pressures for women wearing soft-tissue-borne dentures,[9] which is 25 to 30 pounds of pressure.

A full lower implant denture and an upper tissue-borne denture were constructed on June 18, 1952. A new base was made on the lower jaw. The base

was allowed to rest only on the posts of the implant, so the pressures exerted by the patient would be directed to the osseous structure and not to the mucosa. Immediately after complete healing had occurred periodic pressure registrations were made.

Fig. 1 indicates that it took the patient some time to bring the muscles of mastication back from a state of disuse atrophy to one of efficiency. However, in four months time, this patient registered 64 pounds of closing force which was,

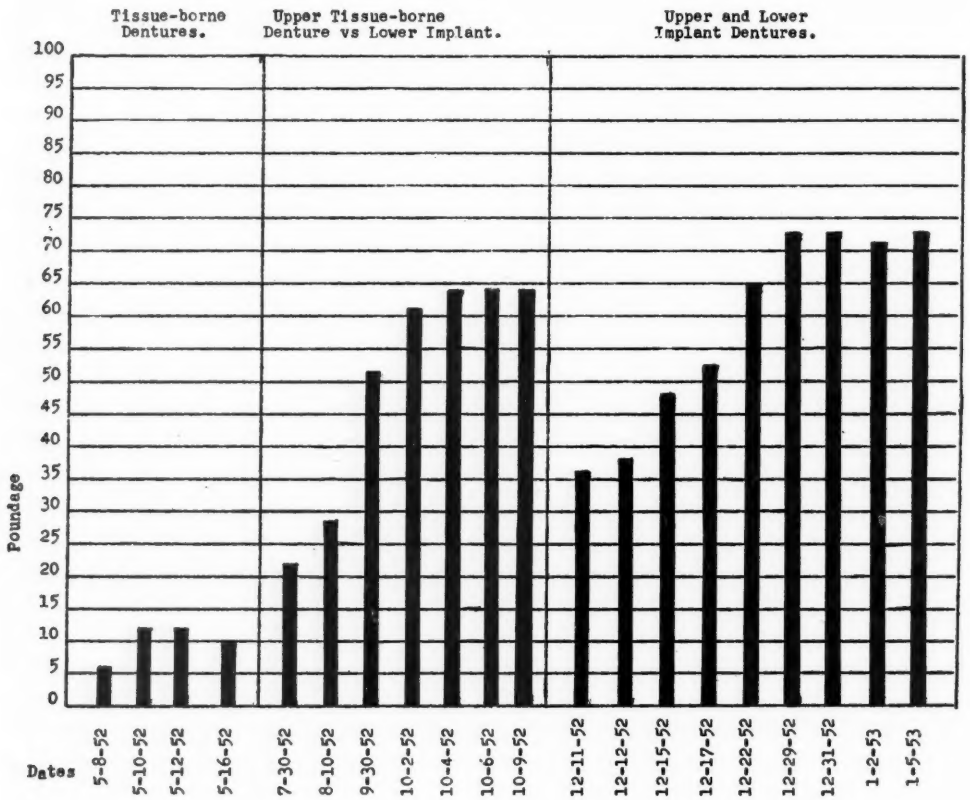

Fig. 1.

apparently, the most pressure she was able to exert. Each time the registration of pressures were made the patient complained of pain in the anterior region of the maxilla and not on the mandible.

On Oct. 30, 1952, the upper implant casting was inserted and the healing was uneventful. The superstructure was inserted on Dec. 10, 1952. A base was constructed for the upper jaw which rested only on the implant posts, and which had a central bearing plate in the palatal vault. A series of pressure registrations was started on Dec. 11, 1952. The first registration showed an exerted force of 36 pounds (Fig. 1). This is a decline from the 64 pounds that the patient exerted

before the upper casting was placed. Due to the inability of the patient to masticate properly while the surgery and healing were taking place, there was a loss of muscular power. The patient recovered this muscular power rapidly, so that at the registration on Jan. 5, 1953, the patient registered 73 pounds of force without experiencing any pain.

DISCUSSION

In this comparative study, the results are from one patient. However, the author would be the first to state that this does not provide us with a ratio nor conclusive proof of an increase for all patients, due to differences in weight, muscle power, age, and sex, but *any* increased function we are able to provide the debilitated denture patients is a great accomplishment for these "denture cripples."

The tests show biting pressures exerted by patients can be increased by means of a plant denture. In this instance, the increase proved to be seven times greater with the implant than with the soft-tissue-borne dentures.

The results of these tests of biting force indicate that proper masticatory function can be restored to the edentulous patient by means of an implant denture. It insures him of retention and stability of his dental prosthetic appliance. Through the improved function (due to greater stability), the patient can improve the tone of atrophied muscles of mastication so he can develop an increased biting force. As a consequence, the patient can increase his biting pressures.

The muscles of mastication, atrophied by disuse, can be restored to normal or nearly normal action. Since the implant rests directly on the osseous structure, and not the mucosa, greater biting forces can be exerted. This, in turn, permits disused muscles to regain all or part of their former power. It can be seen readily that increased biting pressures and increased muscle power are interdependent.

Whether there are differences in the bone beneath a soft-tissue-borne denture and an implant denture cannot be determined solely by roentgenographic examinations. There are too many variables involved,[12] and concrete evidence cannot be available without further case histories, as well as exhaustive tests on laboratory animals. This work is being undertaken by the author.

CONCLUSIONS

Implant dentures provide edentulous patients with nearly complete restoration of masticatory function. The physiologic and psychologic demands,[13, 14, 15, 16] of these patients are met. When the patient is psychologically depressed due to his inability to tolerate conventional dentures in any phase, the construction of implant dentures should be considered very seriously. Schlosser[3] felt this statement was important enough to italicize in regard to artificial dentures: "Such substitutes should have the appearance and perform the functions of the normally arranged natural teeth, and no effort should be considered too great to accomplish these ends."

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Seattle 1, Wash.

PLASTIC COPINGS

Self-polymerizing acrylic may be used for copings for three-quarter or full crowns, and for some inlays.

Steps: 1. The die is coated with an alginate separating medium.
2. The acrylic is painted on the die with a brush.
3. After the acrylic is set, wax is applied and the occlusion perfected.

The plastic coping prevents distortion in handling all wax crowns, and burns out readily prior to casting.

—Gerald Bellagamba

A SIMPLIFIED DEVICE TO ATTACH THE DISTAL EXTENSION TO THE DENTURE OF A CLEFT PALATE PATIENT

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THE CONSTRUCTION of prosthetic appliances for patients with cleft palates frequently presents unusual difficulties due to variations inherent to this type of anomaly. When the defect is limited to the hard palate, the obturation is relatively simple. However, when the soft palate or both the hard and soft palate are involved, the problem is much more complex.

The success or failure of an obturator depends upon several factors: (1) The ability of the dentist to cope with the situation: (a) technical ability, and (b) plan of procedure; (2) the stability of the supporting area; (3) the cooperation of the patient; (4) the variable factor of the denture base materials.

Considering that factors two and three are favorable, let us turn our attention to factors one and four. If metals are used, and if we have sufficient bulk for strength, number four can be considered as favorable. The plastic materials cannot be considered to be stable, although they are reasonably accurate. This, then, leaves most of the problem to the dentist. The average dentist has reasonable technical ability, so that leaves only the plan of procedure in question. How shall the dentist proceed?

Some operators complete the muscle trimming for the obturator in the hard and soft palate before the denture is completed and processed. Others will complete the denture leaving a short distal extension, and build the impression of the soft palate cleft later. Prosthodontists have long recognized the need of securing the impression of the cleft in the soft palate after the denture had been completed. Mauk[1] clearly emphasized this fact by illustrating several forms of extensions to be used for this purpose. At that time, however, the main difficulty seemed to be in the inability to reorient the distal extension (the pharyngeal section) to the denture after processing. Olinger, when he uses a hinge, attaches the pharyngeal section some time after the denture has been worn and adjusted. This, we feel, is the most satisfactory method for securing greater comfort and fit, provided the distal extension is accurately positioned. By using the above method, the denture has an opportunity to settle to place, and the impression building and attaching of the obturator is done under relatively stable conditions. The relationship of the distal extension to Passavant's pad is not as likely to change after the completion of the appliance.

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A simple device for attaching an obturator to a denture can be made by any dentist. It is one which we have used with much satisfaction (Fig. 1). The materials used are two stainless steel plates, 0.025 inches in thickness, and two number 256 screws. Two holes are drilled and tapped in the overlapping ends of the stainless steel. The plate is cut to the proper width and length, and the free ends are perforated for retention in the denture base material.

Next, the denture (partial or full) is constructed by the technique chosen for the patient by the dentist, the only difference being that one end of the device is

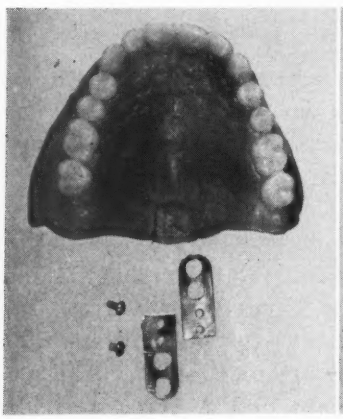

Fig. 1.

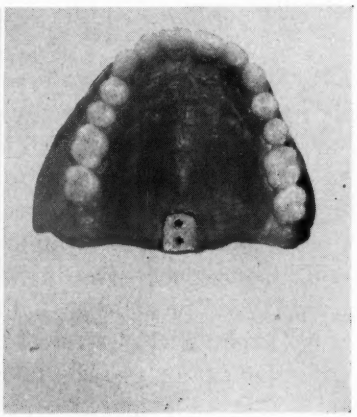

Fig. 2.

Fig. 1.—A denture with the attaching device disassembled.
Fig. 2.—A denture with one-half of attaching device processed in place.

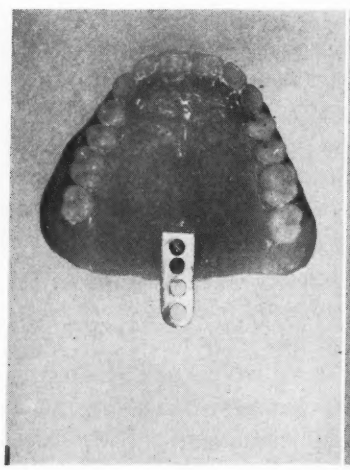

Fig. 3.

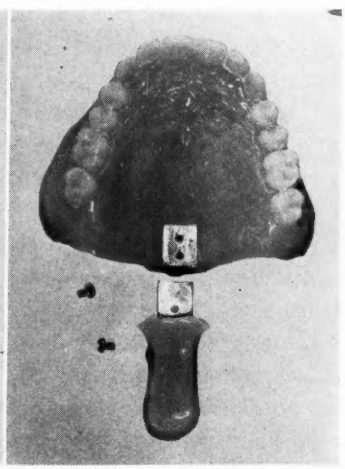

Fig. 4.

Fig. 3.—The second half of attaching device in place prior to the building of the impression of the cleft in the soft palate.
Fig. 4.—The distal extension obturator processed and ready for attachment to the denture.

processed into the palate of the denture so that the overlapping end is even with the distal border of the denture (Fig. 2). The preliminary requirement is that the position and width of the fissure in the soft palate must be determined on the cast. This, of course, will be determined in the master impression. The amount of lateral movement of the lateral border tissues will determine accurately the width and position of the attaching device. The denture is then processed, delivered, and adjusted as necessary. After a period of time, when the denture is comfortable, the impression for the obturator is made. The distal extension of the attaching device is reattached to the part already on the denture (Fig. 3). The impression of the cleft is made at this time. When the proper trimming has been done and a satisfactory impression has been secured, the pattern for the distal extension is removed by removing the screws. The distal extension is then processed in the material of choice (Fig. 4). This accomplished, the distal extension is reattached to the denture with two screws (Fig. 5). The screw heads and plate can be covered with cold-cure acrylic (Fig. 6).

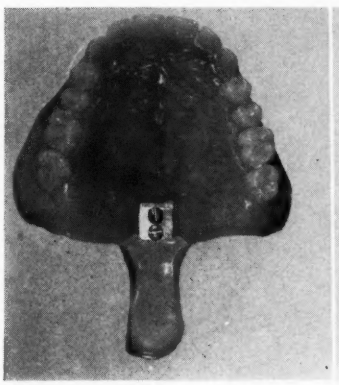

Fig. 5.

Fig. 6.

Fig. 5.—The distal extension obturator in place and attached to the denture with two screws.

Fig. 6.—The completed appliance with the attaching device and screw heads covered with cold-cure acrylic.

SUMMARY

1. The attaching device which was described will insure an accurate positioning of the distal extension on a denture for a cleft palate patient.

2. Separate processing of the denture and the obturator will avoid dimensional change in the denture as a result of reprocessing when the obturator is added.

3. The impression of the cleft in the soft palate is secured under relatively stable conditions.

4. The attaching device permits the impression for the obturator to be muscle trimmed with a comfortably adjusted denture as the supporting device.

5. The attaching device permits the prosthodontist to secure an accurate impression under functional conditions, with a minimum of haste, for as a rule the soft tissues in the cleft do not trim the impression material readily.

6. The attaching device permits the patient to wear the denture, and go "window shopping" during he final stages of building the impression if the proper impression material is used.

7. Adjustments of the obturator are usually unnecessary after delivery.

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TO PREVENT CORROSION BY ACID FUMES

To prevent corrosion of office equipment by acid fumes arising from an open pickling dish, use orthophosphoric acid to which 3 to 5 per cent of hydrochloric acid has been added. It works best at low heat. Gold can be dipped in the acid and heated in a flame. Prolonged boiling in a porcelain dish will attack the dish but not the teeth.

—Clarence H. Blanchard

TO CLEAN COMPOUND FROM A TRAY

Vaseline well and hold the tray in a flame for a few seconds, then wipe it off with a paper towel.

—Mark S. Skiff

Readers' Round Table

Dunedin, New Zealand

The Editor, Journal of Prosthetic Dentistry:

I am pleased to see that your courage and impartiality in publishing my article on the face-bow has been rewarded by some show of interest among your readers. Since you have already been generous with space I shall not pursue the matter. Even a complete and irrefutable disproof of my contentions would provoke me into nothing more than a brief but grateful acknowledgment to anyone who could provide it. Until then, I merely note that my heretical conclusions on the subjects of condyle path records and face-bows are not acceptable to Doctor Siegel (J. PROS. DENT. **3**:289, 1953). I am almost indifferent to and did not expect their acceptance. My concern is with their truth.

Yours sincerely,

F. W. CRADDOCK

News and Notes

ANNOUNCEMENTS

The 1953 annual meeting of the American Denture Society will be held Friday and Saturday, Sept. 25 and 26, 1953, at the Hollenden Hotel in Cleveland. Members should make their hotel reservations at once on the blanks furnished by the American Denture Society.

The American Academy of Implant Dentures will meet in Cleveland, Ohio, in the Allerton Hotel on Sept. 27, 1953. For reservations, write to Dr. William E. Barb, 668 E. Maple Road, Indianapolis, Ind. For further information, write to Dr. M. W. Mueller, 1172 Lowry Medical Arts Bldg., St. Paul, Minn.

The Indiana University School of Detinstry announces a one week postgraduate course in Crown and Bridge Prosthesis, Oct. 19 to 23, 1953. For further information write to Dean Maynard K. Hine, Indiana University School of Dentistry, 1121 W. Michigan St., Indianapolis, Ind.

The next Greater New York Dental Meeting will be held at the Hotel Statler, Dec. 7, 8, 9, 10, and 11, 1953.

Columbia University School of Dental and Oral Surgery of the Faculty of Medicine announces a course on the Principles of Occlusion by Dr. Lewis Fox and associates on January 13, 14, and 15, 1954. For further information write to Dr. Barnet M. Levy, Director, Postgraduate Division at 630 West 168th St., New York 32, N. Y.

On November 11, 1953, the Washington Alumni Chapter of Alpha Omega Fraternity will again present its annual All Day Clinic at the Shoreham Hotel. The theme of the meeting is AN ANALYSIS OF PROSTHETIC DENTISTRY. The speakers will be Dr. Joseph Landa of New York, on full denture prosthesis, Dr. Morton Amsterdam of Philadelphia, on fixed prosthesis and mouth rehabilitation, and Dr. L. G. Coble of Greensboro, North Carolina, on occlusion. The symposium will be moderated by Ernest Nuttal of the University of Maryland in Baltimore.